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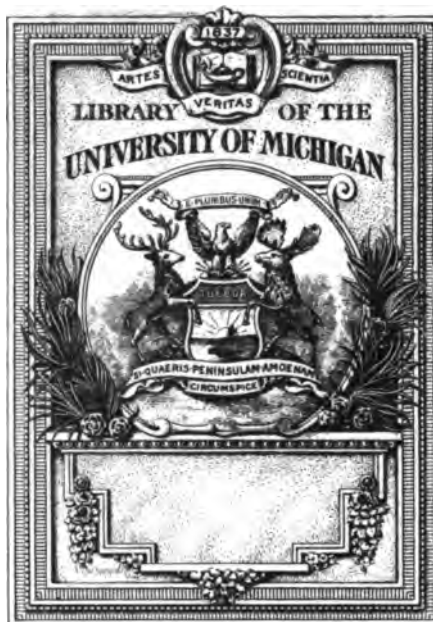
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U. S. DEPARTMENT OF AGRICULTURE,
U. S. WEATHER BUREAU.

Bulletin D.
(Part 7 in Weather Rept 1896-7 as bound in Serial no. 3670)

RAINFALL OF THE UNITED STATES,

WITH

ANNUAL, SEASONAL, AND OTHER CHARTS.

Prepared under the direction of
WILLIS L. MOORE,
CHIEF OF THE WEATHER BUREAU,

BY
ALFRED J. HENRY,
CHIEF OF DIVISION.



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LETTER OF TRANSMITTAL

U. S. DEPARTMENT OF AGRICULTURE,
WEATHER BUREAU,
Washington, D. C., August 7, 1897.

SIR: I have the honor to submit herewith a report prepared under my personal supervision by Mr. Alfred J. Henry, Chief of Division, entitled Rainfall of the United States, and to recommend its publication as a bulletin of the Weather Bureau.

The facts and conclusions presented in the report have been drawn from the longest and at the same time the most reliable rainfall registers in the United States; the averages have been compiled to the end of 1896; in short, it has been the aim to present the most comprehensive survey of the subject possible with the time and means at command.

The rainfall of the crop-growing season has received separate treatment—a departure from the usual methods much to be commended, for however important a knowledge of the water supply throughout the whole year may be, it is conceived that information as to the amount of rainfall available for agricultural purposes is of greater consequence.

The division of the area under discussion into rainfall districts according to their natural boundaries is manifestly an important feature of the work, since it simplifies the general conception of the problem and affords an easy and natural method of studying the vicissitudes of rainfall in the United States.

Very respectfully,

WILLIS L. MOORE,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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RAINFALL OF THE UNITED STATES.

INTRODUCTION.

It is quite probable that rain falls in the United States at one point or another every day of the year. On very rare occasions the observers of the Weather Bureau report no precipitation at a given hour, but it should be remembered that their range of vision can cover at the utmost less than one-hundredth part of the whole area.

The theories of rainfall given in the books of twenty or thirty years ago are not now wholly accepted. There is one very simple principle, however, upon which no disagreement exists, viz, that in order to produce abundant rain the temperature of air must be suddenly cooled below the dew-point. When the air is thus cooled, a portion of the water vapor which is always present within it is changed to the liquid state, and that which formerly existed as a gas or vapor now becomes visible in the form of minute particles of fog or mist. The particles thus formed may float away with the wind or they may increase in size, coalesce, and fall to the ground of their own weight. Whether the condensation of vapor thus outlined results simply in cloud, or whether rain falls, depends on the magnitude of the temperature changes that take place in the air mass whose vapor is being condensed. A rise in temperature is inimical to further condensation; a fall is favorable to precipitation.

The precise manner in which air is cooled sufficiently to produce rain, whether by contact or by mixing, is not clearly apprehended. Cooling by expansion as air ascends is one of the most effective causes of rainfall. The ascensional movement of air is brought about in several ways, chief of which are: (1) The air may be forced up the side of a mountain into a region of diminished pressure and lower temperature, as happens whenever a mountain range runs in a direction at right angles to the prevailing winds; (2) in the warm season, the lower layers of the atmosphere under the effect of solar radiation, and probably other causes, frequently reach a state of unstable equilibrium, thus inducing ascensional currents—summer thunderstorms are largely a result of this process; (3) last, and doubtless most important of all, is the circulation of air in cyclonic storms, viz, a radial inflow from all sides and an ascensional movement in the center. A very large percentage of the rain of the United States is precipitated in connection with the passage of storms of the latter class.

The conditions which affect or control the rainfall may be divided into two classes, permanent and variable. The permanent conditions which contribute to an abundant rainfall are chiefly: (1) Nearness to the ocean or other large body of water; (2) a location within or near the track of cyclonic storms; (3) mountain ranges, particularly those running in a direction at right angles to the direction of the rain-bearing winds. These conditions may operate singly or in combination. Condition 1 alone is not always effective in producing rainfall, as witness the South Pacific Coast; likewise condition 2 alone is not so effective in the interior of continents far removed from an abundant supply of vapor, as in coastal regions. Montana and North Dakota, while lying directly within one of the great storm paths, are too far removed from the ocean to receive abundant rainfall, although other conditions are favorable.

The rainfall of the North Pacific Coast is an example of the combined effect of all three conditions.

The permanent conditions unfavorable to rainfall are chiefly those of geographic position, whether (a) on the leeward side of a mountain range running in a direction at right angles, or nearly so, to the prevailing winds; (b) at a considerable distance from the average track of barometric depressions; or (c) remoteness from the ocean.

The variable conditions which influence rainfall are the concomitant changes of pressure, temperature, and wind movement. If we attempt to analyze these forces, we are at once led to the greater problem of the general atmospheric circulation and the modifying effect thereon of the North American Continent—a matter not within the scope of this discussion.

In general, the two classes of conditions which influence precipitation are so blended that it is difficult to assign a quantitative value to the effect of each. We may say, in general, the rainfall of any given place will range between limits previously ascertained by observation, but the character of the fall, whether light or heavy, depends, as before stated, on the daily changes of pressure, temperature, etc., which, in the present state of knowledge, can not be foreseen except for a short time in advance.

It is proposed to discuss the precipitation of the United States under the following topics, in the order named: I. The statistics used and their accuracy; II. Geographic distribution, annual amounts; III. Monthly distribution by districts and types; IV. The precipitation of the crop-growing season; V. Secular variation; VI. Details of precipitation by geographic districts; VII. Excessive precipitation.

I.—STATISTICS USED AND THEIR ACCURACY.

The exposure of the rain gauge.—In analyzing and comparing a large number of rainfall registers, covering different periods of time and made under varying conditions of gauge exposure, it is desirable that inquiry be made at the outset as to the dependence that can be placed upon them.

The problem of measuring the rain and snow that falls would appear at first sight to be quite simple; yet it is beset with many difficulties. It was discovered many years ago that the catch of a gauge on the roof of a building was less than on the ground, and many experiments have since been made with a view of determining the variation of rainfall with altitude above ground.

The experiments carried on under the direction of Dr. G. Hellman, of the German Meteorological Society of Berlin, for a period of seven years, lead to the following conclusions: The more a rain gauge is exposed to the wind, other circumstances being equal, the less rainfall it records, and the greater the altitude of the gauge above ground the less rain it collects, since the disturbing action of the wind is greater than on the surface of the ground. If, however, a gauge is properly protected from the wind, useful results may be obtained even in an elevated position.

Weather Bureau rainfall registers are derived almost wholly from roof exposures, and this must naturally be the case whenever an observing station is located in the midst of a large city. Moreover, the exigencies of the service often require changes from one building to another, thus breaking the continuity of the environment of the gauge and adding an element of probable uncertainty to the recorded results. Accepting the general principle that the depth of rain as determined by roof gauges falls short of the true amount, it is next of importance to ascertain the actual amount of the deficiency.

Comparison of roof and ground exposures.—Fortunately, for purposes of comparison between roof and ground gauges, independent rainfall observations have been made at a few points in rather close proximity to Weather Bureau gauges. At St. Louis, Mo., a series of rainfall measurements have been made at Forest Park, almost 4 miles due west of the Weather Bureau office. The rain gauge at the park is exposed in an open space, about 75 feet from the nearest object. The top of the receiver of the gauge is 4 feet above ground. The Weather Bureau office in the city is domiciled directly under the dome of the city post-office and custom-house. The rain gauge is placed on the roof, about 20 feet back from the edge and 100 feet above the street. It is fairly typical of the best of roof exposures in other cities. A comparison of the records of rain and melted snow at the two stations for the five years 1891–1895 shows that the catch of the Weather Bureau gauge in winter is slightly greater than that of the park. In the warmer months, particularly May and June, the park gauge catches the greater amount. On the average of the year the excess of the park above the Weather Bureau is about 2 inches, or 5 per cent. The rain gauge at the Philadelphia office of the Weather Bureau is situated on the roof of the post-office building, 166 feet above ground. Mr. L. M. Dey, the official in charge of that station, has made a set of comparative readings between the post-office building gauge and a ground gauge at a point 3 miles east. The ground gauge, on the average of six years' observations, catches 3 inches

(8 per cent) per annum more than the roof gauge. Other comparative readings in the vicinity of Philadelphia give substantially the same result. Mr. Dey, who has given the matter some study, is of opinion that the deficiency in the catch of the roof gauge is due to counter wind currents caused by the dome-shaped roof of the building.

In New York City a comparison between the rainfall registers made at the Weather Bureau office on lower Broadway, at an elevation of about 150 feet above the street, and in Central Park, at an elevation of 63 feet above the surface of the ground, for a period of twenty years, shows the catch of the Weather Bureau gauge to be 2.17 inches per annum (5 per cent) greater on the average than the Central Park gauge. In general, however, it does not seem possible to avoid the conclusion that the absolute amount of precipitation as registered by Weather Bureau gauges falls short of the true amount by quantities varying from 5 to 10 per cent of the annual fall.

Heretofore, in dealing with the statistical aspect of the subject, it has been sufficient to accept the available registers of the various geographic districts, whether of ten or twenty years' duration, as representing the true average precipitation.

The inquiry, what constitutes a true normal, is of considerable economic importance, in view of the fact that the average length of continuous rainfall registers in some of the States is less than ten years. The extensive western movement of settlers within the transmississippi section some years ago was influenced in a great measure by several successive years of abundant rainfall. There was an undercurrent of opinion, moreover, that the increased rainfall was in some measure due to the permanent occupation of the major portions of eastern Kansas, Nebraska, and adjacent States by an agricultural population. It was argued, and with some show of reason, that the breaking up of the prairie sod and the cultivation of the soil over such a large extent of territory must increase local evaporation, and consequently the rainfall. It will be shown on subsequent pages, however, that years of "fat" and "lean" rainfall do not alternate in orderly sequence, and that a number of consecutive years of heavy rains can not safely be accepted as indicating a permanent increase in rainfall.

A true normal may be defined as one which will not be materially altered, however long the observations may be continued. In order to reach a conclusion as regards the least number of consecutive years that will satisfy such a condition, several of the longest continuous registers of the United States were examined. The rainfall of eighty-three consecutive years has been measured at New Bedford, Mass. At St. Louis, Mo., the combined registers of Dr. George Engelman and the Weather Bureau cover a period of sixty years. Registers have also been maintained for many years at Philadelphia, Pa.; Cincinnati, Ohio; Fort Leavenworth, Kans., and at other places. It is not possible to obtain a statement of the details of exposure and methods of observation at each of the stations. In fact, there is a notable absence of historic details respecting all but a very few of the rainfall records that extend as far back even as 1850. The writer does not know of a single rainfall register that was established and has been perpetuated under ideal conditions of environment and observational accuracy. The New Bedford register has the merit of being kept by but two persons, the late Samuel Rodman and his son, Thomas R. Rodman, the present voluntary observer of the Weather Bureau for New Bedford.

The possible error of short-period rainfall registers.—In order to obtain the extreme variation or possible error of a ten-year period, the average of the first ten years of each register (1–10) was computed; then, dropping the first year, the average of the second period of ten years (2–11) was computed. Proceeding in like manner, 74 separate combinations of ten-year periods were obtained for the New Bedford record. Had observations been made during the ten years 1884–1893 only, the annual average, if computed from that period, would have been 50.4 inches, whereas the true annual average, as determined from the eighty-three years, is 43.5 inches. On the other hand, had the years 1837–1846 been used, an average of 38.8 inches would have been obtained. The *extreme* variation or actual error in the first case would have been 16 per cent; in the second, 11 per cent of the mean annual fall, the deviation above and below the mean being computed separately. In like manner the *extreme* variations in a ten-year period at Cincinnati were found to be 20 and 17 per cent, respectively; at St. Louis, 17 and 13 per cent; at Fort Leavenworth, 16 and 18 per cent, and at San Francisco, 9 and 10 per cent.

Increasing the number of years and proceeding as described above, it was found that the *extreme* variation of a twenty-five-year record, which is about the period covered by the combined observations of the Signal Service and Weather Bureau, was 10 per cent, both at New Bedford and St. Louis.

The conclusion is reached that at least thirty-five or forty years' continuous observations are required to obtain a result that will not depart more than ± 5 per cent from the true normal, even if the register be continued indefinitely. The *average* variation of a twenty-five-year period is about ± 5 per cent, and of a forty-year period about ± 3 per cent; that is to say, if any period of twenty-five years be selected from a register extending over eighty years, the average of the twenty-five-year period may be 5 per cent above the true normal, or it may be 5 per cent below it.

It is not intended that too great stress shall be put upon these facts, but rather to direct attention to the need of caution when dealing with short-term averages, especially when the period of observation is less than twenty years. The true normal precipitation of a large portion of the United States has not yet been accurately determined; indeed, as will be shown on subsequent pages, twenty-year averages have, in some cases, been reduced by from 5 to 8 per cent by the addition of the five years 1892-1896.

II.—GEOGRAPHIC DISTRIBUTION.

General features.—The distribution of rain and snow over the United States is graphically shown on Chart I. The registers used in the preparation of this chart were those of Weather Bureau stations that have been in operation since 1870, supplemented, in many cases, by private registers kept by cooperating voluntary observers. Probably a third of the whole area is represented by less than twenty consecutive years of observation, a period not long enough, as above stated, to determine the average fall with great accuracy.

The main facts regarding the geographic distribution of precipitation in the United States, as shown by the chart, are as follows: There is a narrow belt of very heavy rainfall on the Northwest Coast, extending from Cape Flattery on the north to midway of the Oregon Coast on the south, and inland as far as the summits of the Coast Range, including in that designation the main and collateral ranges of mountains extending from southern Oregon to the Straits of Fuca. Eastward and southward the annual fall diminishes, reaching a minimum on the lowlands and valleys included between the Coast Range on the west and the Sierra Nevada and the Cascade ranges on the east. The precipitation increases from the valleys to the mountain tops, thence falls away very rapidly with descent on the eastward slope until the great plateau is reached. Here the fall ranges from 5 to 15 inches, with isolated areas where it rises to 20 inches and over. There is but little increase as the western slope of the Rocky Mountains is reached, except in central and northern Idaho.

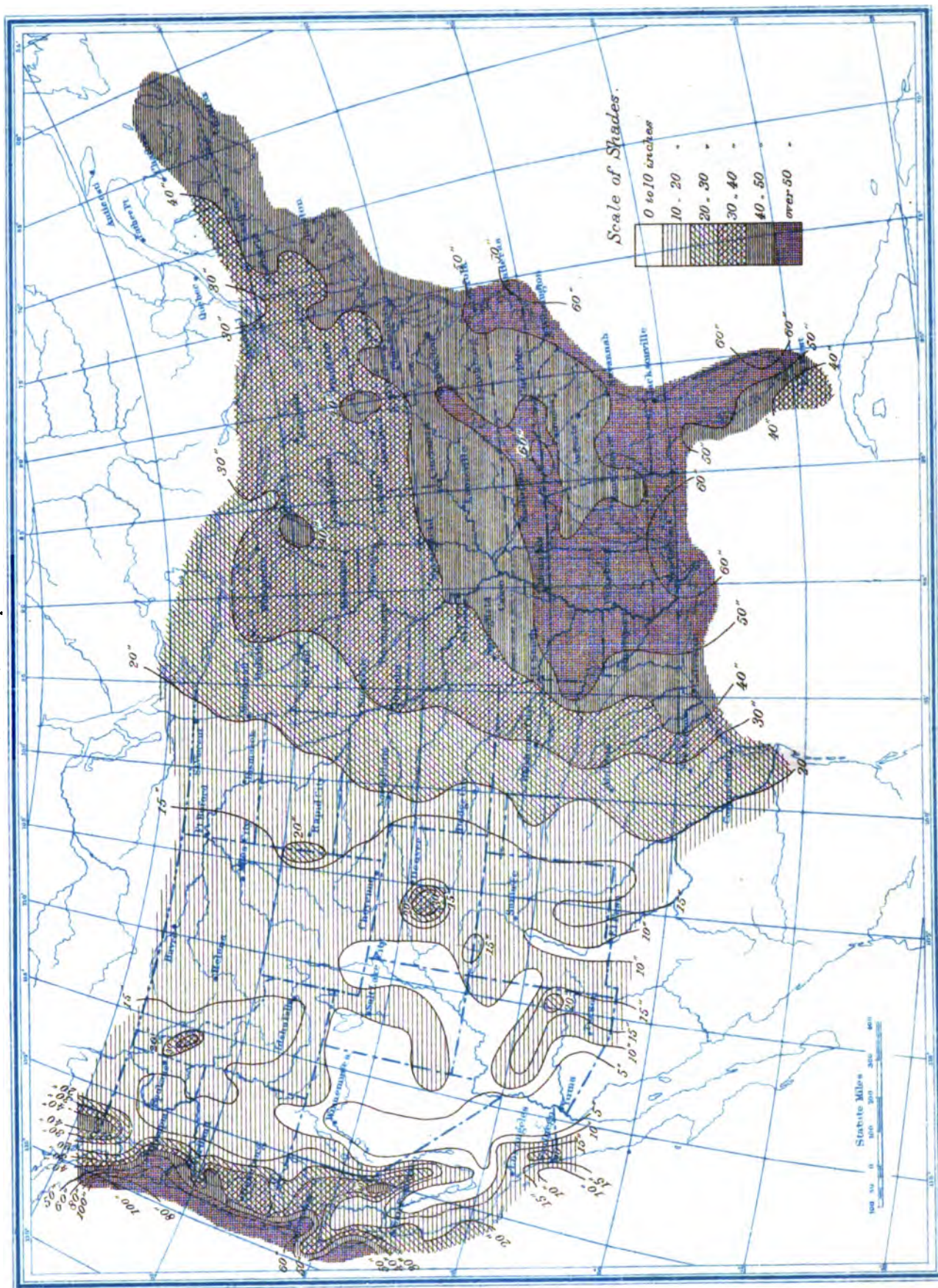
The precipitation on mountain slopes and summits is known to be large, but a quantitative statement of the annual depth can not yet be made. The rainfall of the foothills region east of the Rocky Mountains ranges from 10 to 18 inches, and it increases slowly toward the one hundredth meridian. Eastward of that meridian the annual precipitation varies from a little under 20 inches to about 60 inches on the Florida and Gulf coasts. There is a gradual decline both from the Atlantic Coast westward and from the Gulf Coast northward. The diminution in fall from New Orleans northward to St. Paul is 32 inches; from Eastport westward to St. Paul, 12 inches.

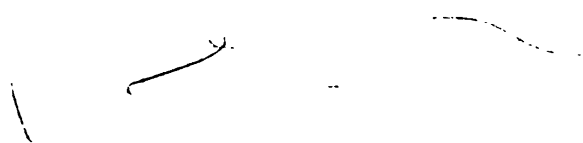
Further information regarding the distribution of precipitation by districts will be found, under Topic 5.—Details of precipitation by geographic districts.

Addition of five-year period, 1892-1896, effect of on averages.—The last official rainfall bulletin issued in 1894, contained the monthly and annual averages to the end of 1891. (Bulletin C.—Rain and Snow of the United States.) The addition of the five-year period 1892-1896 does not materially change the normals or averages heretofore determined, except over the west Gulf Coast, where the old normals have been reduced between 3 and 4 inches per annum at several stations having twenty years of continuous observations. There is also a reduction in the normals of Tennessee and North Carolina of from 1 to 3 inches, and, generally, there is a slight reduction over the Mississippi and Ohio valleys and the eastern seaboard as far north as New York City. On the other hand, there is a slight increase on the Pacific Coast and at isolated stations in the arid regions.

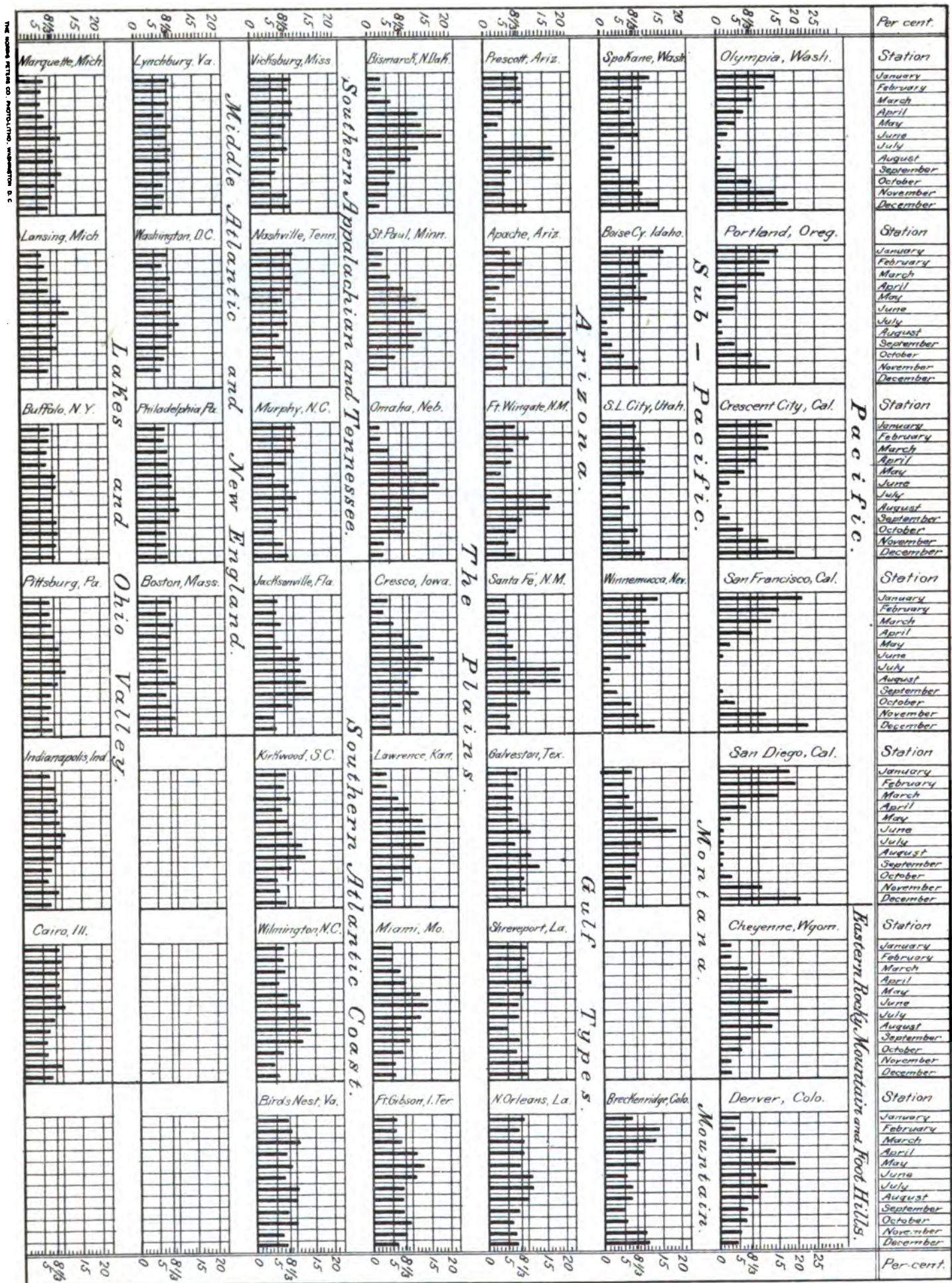
Chart I.

Mean Annual Precipitation.





Types of Monthly Distribution of Precipitation in the United States.
Rainfall Distribution in the U. S. (Percentage of fall in each month represented by heavy vertical lines.)



During the greater portion of the period 1892-1896 drought prevailed in many parts of the United States. It will be instructive, therefore, to compare the rainfall of the last five years with the averages as deduced from observations of former years. One hundred and three stations were used in the comparison, 25 of which showed a rainfall during the five years greater than the average. These were distributed as follows: 14 on the Pacific Coast; 2 in Wyoming; 2 in New York; 1 each in Montana, New Mexico, Minnesota, Kansas, Ohio, Virginia, and South Carolina. At the remaining 78 stations the rainfall was less than the average; at some stations decidedly so. The greatest deficiency—a little over 10 inches per annum on the average—was registered at the 4 stations, Vicksburg, Shreveport, New Orleans, and Galveston.

III.—MONTHLY DISTRIBUTION BY DISTRICTS AND TYPES.

The fundamental data upon which all questions of water supply must depend are the monthly amounts of rainfall. Tables of annual precipitation tell us how much rain or snow falls on the average during the course of a year, but they afford no indication, directly or indirectly, as to whether the rain comes when it will be of the greatest service to agriculture or whether it falls after the time of maturity of the staple crops.

If the precipitation of the year were evenly distributed each month would receive $8\frac{1}{3}$ per cent. To discover the proportion that is received each month throughout the United States is the object of the present chapter.

For convenience of comparison the monthly averages of a number of selected stations have been reduced to percentages of the annual fall. Classifying these by geographic districts it is soon noticed that the distribution over comparatively large areas is practically uniform and that the profile of a single station may be safely used to represent the distribution of the entire district. If now the geographic limits of the districts having different rainfall conditions be ascertained, it will be of material aid in reaching a clear conception of the rainfall system of the United States. We shall find that, generally, a single set of conditions operates to modify or control the rainfall of the various geographic districts, and we may, therefore, view the rainfall of the United States not as a single concrete system, but rather as being composed of a number of separate and distinct types as follows, viz:

Pacific, sub-Pacific, Arizona, Mountain, Eastern Foothills, Plains, Gulf, Southern Appalachian and Tennessee, South Atlantic, Middle Atlantic and New England, Lake Region and Ohio Valley.

Pacific type.—This type is found in all of the territory west of the Cascade and Sierra Nevada ranges, and also obtains in a fringe of country to the eastward of the mountain summits. It is represented by the profiles of Olympia, Wash.; Portland, Oreg.; Crescent City, San Francisco, and San Diego, Cal. (Plate I.) The heavy black vertical lines represent the precipitation of each month expressed as a percentage of the annual fall. A light horizontal line has been inserted at the point on the vertical scale corresponding to $8\frac{1}{3}$ per cent for convenience in comparing the distribution at the different stations, it being remembered that if the precipitation were uniformly distributed throughout the year the heavy vertical lines would terminate at the point where they intersect the line of $8\frac{1}{3}$ per cent.

The distinguishing characteristic of the Pacific type is a wet season, extending from October to March, and a practically rainless summer, except in northern California and parts of Oregon and Washington. About half of the yearly precipitation comes in the months of December, January, and February, the remaining half being distributed throughout the seven months, September, October, November, March, April, May, and June.

Sub-Pacific.—The term "sub-Pacific" has been given to that type of rainfall which obtains over eastern Washington, Idaho, Nevada, and Utah. The influences that control the precipitation of this region are much similar to those which prevail west of the Sierra Nevada and Cascade ranges. There is not, however, as in the Pacific type, a steady diminution of the winter precipitation with the approach of spring, but rather an increase which culminates in the late spring months. (See the profile of Spokane.) This fact is of very great importance to agricultural interests, whether the natural rainfall is sufficient for the growth and maturity of staple crops or not. In the latter case the rain comes at a time when most needed for irrigation. Salt Lake City has been placed within the sub-Pacific group, although its profile is not similar in all respects to those of the remaining stations. The differences are probably due to the influence of the lake.

Arizona.—The Arizona type, so called because it is more fully developed in that Territory than elsewhere, prevails over Arizona, New Mexico, and a small portion of southern Utah and Nevada. This type, of which Prescott, Fort Apache, Fort Wingate, and Santa Fe are examples, differs from all others in the fact that about 35 per cent of the rain falls in July and August. May and June are generally the months of least rainfall. The summer rains are essentially a feature of the mountain and plateau systems of both Territories, and are believed to be due largely to local convection induced by excessive insolation on the barren, rocky surface of the mountain sides and summits. The winter rains are believed to be due to migratory areas of low pressure pertaining to the general system of storm movement. The character of the winter rains, whether light or heavy, depends largely on the frequency of atmospheric disturbances and especially their movement in latitude.

Mountain.—The Mountain type is represented on the diagram [Plate I] by one station only, Breckenridge, Colo., situated on the western divide of the Rocky Mountains at an elevation of about 9,500 feet above sea level. The observations extend over a little more than seven years, and the type is, therefore, a provisional one only. It is characterized by heavy snowfall in the winter and spring months and a secondary maximum of rain in July and August, and seems to stand in rather close relation to the Pacific and Arizona types.

Montana.—The rainy season in Montana is confined to May and June, 33 per cent of the annual amount falling in these months. The rainfall of the remainder of the year, although small, is well distributed for agricultural purposes.

The Eastern Foothills.—A type closely allied to that of the Plains to the eastward. The Rocky Mountains form a dividing line between diametrically opposite rainfall types. West of the mountains, except in Arizona and New Mexico, the bulk of rain falls in the colder months of the year, but on crossing the range, the rainy season is transferred to the warmer months. In the Foothills region it occurs in April and May; in Montana, in May and June. On the Plains proper and eastward to Michigan and Indiana, it falls in May, June, and July, while on the South Atlantic and Gulf coasts it occurs in August and September, with but few exceptions.

The rainfall of the Eastern Foothills region is not abundant, but what there is comes at the most opportune time of the year. This type is represented by the profiles of Denver and Cheyenne.

The Plains.—The Plains type is a very important one, covering as it does the great wheat and corn region of the interior valleys. It embraces the greater part of the Dakotas, all of Minnesota and Wisconsin, part of Michigan and Illinois, all of Iowa, Nebraska, and Kansas, and the greater part of Missouri. This extensive region is characterized by a scant winter precipitation over the more northern States and moderately heavy rains during the growing season.

The profiles for Bismarck, N. Dak.; St. Paul, Minn.; Omaha, Nebr.; Cresco, Iowa; Lawrence, Kans., and Miami, Mo., illustrate the general features of the Plains type. The winter precipitation of the group decreases with increase of latitude, and there is a secondary maximum in September near the Great Lakes, as may be seen by examining the profiles of St. Paul and Marquette.

The rain of the Plains comes almost wholly as summer thundershowers, and in connection with migratory areas of low pressure that pass across the country.

Gulf.—The Gulf type is more complex than any of those hereinbefore considered. The distribution throughout the year is also more uniform, comparatively few months receiving less than 8½ per cent of the yearly fall. On the west Gulf the rainfall of June, August, and September is heavier than at other seasons of the year. The maximum of the year on the middle coast, as in Alabama, occurs in March; on the Florida coast in August and September.

Southern Appalachian and Tennessee.—This type has its chief maximum in the late winter and spring, and its chief minimum in October. It prevails in northern Mississippi, Tennessee, western North Carolina, extreme northern Georgia, and northeastern Alabama. The rainfall on the southern extremity of the Appalachian system is quite heavy, and is exceeded only by the rainfall of western Washington and Oregon.

South Atlantic.—Includes the South Atlantic Coast from Virginia southward to Florida. The time of maximum rain in this region is deferred until the months of July, August, and September—the season of subtropical rains in Florida and on the Gulf Coast.

Middle Atlantic and New England.—The distribution of rain in this region is more uniform than in any other part of the country. The range between months of greatest and least rainfall is very small and of but little practical importance.

Lake region and Ohio Valley.—The distribution in the upper Lake region approaches closely to that of the Plains, with the exception of a second maximum of rain in September, hereinbefore mentioned. The rainfall of the Ohio Valley differs chiefly from that of the Plains in the greater amount that falls in the winter. This is to be expected, since the atmospheric disturbances that originate in the Gulf region and Texas generally pass directly over the valley, giving copious rains in front and on the south side of the storm's path.

IV.—THE PRECIPITATION OF THE CROP-GROWING SEASON.

Pacific Coast compared with the East.—The rainfall conditions of the Pacific Coast are quite different from those of the East, as has been stated on the preceding pages. Grain sown in the fall begins to sprout with the first rain, and thenceforth grows more or less slowly throughout the winter. It is ready for the reaper from the 1st of June to the 1st of July, according to latitude, and with the harvest comes the end of the rains. Fall-sown grain in the East makes little, if any, growth during the winter, but with the advent of warm weather in the spring the plant grows rapidly under favorable conditions of heat and moisture. April to August may therefore be called the critical months for the staple crops in the eastern two-thirds of the United States, and it is with the rainfall of these months that the agriculturist is chiefly concerned. The tables below show the normal rainfall of each month of the growing season, including September, the total for the season, the greatest and least seasonal fall during the period of observation, and the ratio of the seasonal to the annual fall.

TABLE I.—Monthly and seasonal averages of rainfall, etc.

Stations.	Latitude.	Longitude.	Elevation.	Number of years.	April.	May.	June.	July.	August.	September.	Total.	Maximum.	Minimum.	Year of minimum rainfall.	Percentage of annual.
MAINE.															
Brunswick.....	43 54	69 57	64	20	4.2	4.7	3.8	3.8	4.9	3.2	24.6	37.6	14.7	1846	49
Cornish.....	43 44	70 51	784	40	3.3	3.6	3.5	4.2	4.3	3.4	22.3	34.8	14.9	1880	48
Eastport.....	44 54	66 59	30	23	3.0	3.7	3.5	3.9	3.5	3.2	20.8	30.6	11.2	1894	46
Gardiner.....	44 14	69 43	23	53	3.4	3.8	3.2	3.2	3.6	3.2	20.4	31.4	12.3	1844	47
Orono.....	44 56	68 44	71	24	2.8	3.4	3.4	3.3	3.6	3.4	19.9	29.2	13.4	1895	45
Portland.....	43 39	70 15	12	25	3.0	3.6	3.4	3.6	3.8	3.1	20.5	25.4	15.2	1883	48
NEW HAMPSHIRE.															
Concord.....	43 12	71 32	252	42	2.8	3.3	3.1	3.7	3.9	3.4	20.2	27.6	12.7	1869	50
Hanover.....	43 42	72 49	545	48	2.3	3.2	3.5	3.4	3.7	3.0	19.1	28.9	12.8	1880	53
Lakeport ^a	43 32	71 28	.....	23	2.7	3.3	3.5	4.0	3.8	3.6	20.9	26.9	16.3	1894	49
Stratford.....	44 40	71 39	1,000	24	2.4	3.4	3.4	4.0	4.0	3.5	20.7	31.0	14.1	1870	53
VERMONT.															
Burlington.....	44 28	73 12	268	53	1.9	3.1	3.2	4.0	3.6	3.5	19.3	34.4	11.8	1894	59
Lunenburg.....	44 28	71 41	850	44	2.6	3.6	3.5	3.9	3.8	3.4	20.8	40.8	12.5	1854	53
Strafford.....	43 52	72 24	500	24	2.5	3.3	3.5	4.1	3.7	3.4	20.5	29.4	14.4	1896	52
MASSACHUSETTS.															
Amherst.....	42 22	72 32	235	61	3.1	3.9	3.7	4.5	4.4	3.4	23.0	35.0	14.0	1894	52
Boston.....	42 21	71 04	12	79	3.8	3.7	3.2	3.6	4.3	3.4	22.0	41.7	11.8	1836	48
Fall River.....	41 42	71 09	259	22	3.0	4.0	3.1	3.5	4.4	3.3	22.2	30.4	16.4	1886	44
Fitchburg.....	42 36	71 50	433	32	2.9	3.8	3.3	3.7	4.3	3.2	21.2	32.2	13.5	1883	51
Lowell.....	42 39	71 17	104	42	3.6	3.7	3.3	3.8	4.4	3.3	22.1	34.3	14.5	1883	49
New Bedford.....	41 39	70 56	100	83	3.6	3.8	3.0	3.1	3.9	3.3	20.7	34.8	11.6	1849	48
Springfield.....	42 05	72 35	70	47	3.2	4.2	3.8	4.5	4.5	3.4	23.6	33.2	12.3	1864	52
Taunton.....	41 54	71 05	30	22	3.6	3.3	2.5	3.5	4.2	2.8	19.9	33.1	9.6	1883	44
Worcester.....	42 13	71 49	473	43	3.7	4.1	3.1	3.8	4.5	3.5	22.7	36.0	13.9	1883	49
RHODE ISLAND.															
Providence.....	41 50	71 25	11	65	3.7	3.8	3.3	3.3	4.2	3.2	21.5	34.6	11.3	1836	47
CONNECTICUT.															
Hartford.....	41 45	72 40	38	27	3.0	3.6	3.0	4.1	4.6	3.2	21.5	32.9	13.3	1870	47
New Haven.....	41 18	72 50	10	45	3.3	3.9	3.1	4.5	4.6	3.8	23.2	38.2	16.0	1894	51
New London.....	41 21	72 05	8	26	3.7	3.6	3.2	4.0	4.7	3.4	22.6	42.2	12.6	1894	47
Middletown.....	41 33	72 39	37	33	3.4	3.8	3.5	4.3	4.8	3.6	23.4	37.2	14.2	1894	48
Southington.....	41 35	72 51	152	26	3.1	3.2	2.8	3.9	4.6	2.9	20.5	31.4	12.6	1883	47
Wallingford.....	41 27	72 49	73	35	3.6	4.2	3.6	4.2	5.0	3.6	24.2	37.1	15.0	1881	49

^a Formerly Lake Village.

TABLE I.—Monthly and seasonal averages of rainfall, etc.—Continued.

Stations.	Latitude.	Longitude.	Elevation.	Number of years.	April.	May.	June.	July.	August.	September.	Total.	Maximum.	Minimum.	Year of minimum rainfall.	Percentage of annual
NEW YORK.															
Albany.....	42 40	73 45	32	60	2.8	3.6	4.1	4.2	4.0	3.5	22.2	36.8	14.2	1896	56
Buffalo.....	42 53	78 53	587	27	2.5	3.4	3.5	3.2	3.2	3.3	19.1	32.8	11.4	1881	50
Cooperstown.....	42 42	74 57	1,300	43	2.6	3.6	4.1	4.3	4.1	3.4	22.1	33.4	12.8	1881	57
Gouverneur.....	44 25	75 35	423	21	2.1	2.7	2.7	2.8	2.3	3.1	15.7	30.1	5.4	1842	50
New York.....	40 43	73 58	52	61	3.4	4.0	3.8	4.0	4.7	3.4	23.3	42.6	12.5	1849	52
North Salem.....	41 20	73 84	361	23	3.4	4.4	3.5	4.0	4.1	3.1	22.5	35.2	15.6	1841	55
Rochester.....	43 08	77 42	494	27	2.5	3.3	3.3	3.0	3.0	2.4	17.5	21.7	9.6	1887	50
Ithaca.....	42 27	76 30	375	36	2.2	3.4	3.7	3.5	3.0	3.0	18.8	27.5	11.3	1879	57
NEW JERSEY.															
Atlantic City.....	39 22	74 25	13	23	3.3	3.1	3.0	3.5	4.3	3.2	20.4	33.4	13.8	1895	50
Trenton.....	40 14	74 45	33	24	3.7	4.1	3.9	5.5	5.3	4.0	28.5	39.4	17.4	1895	53
Lambertville.....	40 23	74 57	75	25	3.3	4.4	3.8	4.4	4.9	4.3	25.1	42.3	14.9	1848	54
Newark.....	40 45	74 10	13	52	3.5	4.0	3.5	4.4	5.0	3.8	24.2	40.1	12.1	1881	52
New Brunswick.....	40 30	74 27	48	43	3.7	3.9	3.9	4.7	4.9	3.8	24.9	37.2	11.7	1881	53
South Orange.....	40 45	74 15	141	26	3.3	3.2	3.6	4.0	5.2	4.0	24.2	49.9	12.5	1881	51
Vineland.....	39 29	75 01	97	25	3.3	3.9	3.3	4.3	4.9	4.0	23.7	33.0	14.2	1884	50
PENNSYLVANIA.															
Blooming Grove.....	41 23	75 09	.....	25	3.2	4.0	4.1	5.0	4.9	3.1	24.3	42.8	12.8	1881	55
Dyberry.....	41 38	75 18	1,100	25	2.5	3.4	3.1	4.6	3.8	2.8	20.2	27.5	14.2	1875	53
Erie.....	42 07	80 05	686	23	2.5	3.8	3.9	2.8	3.3	4.0	20.3	27.3	11.5	1891	49
Gettysburg.....	39 40	77 15	624	24	3.5	4.0	3.5	3.4	3.6	3.0	21.0	32.1	11.6	1845	54
Harrisburg.....	40 16	76 53	320	25	3.0	4.6	4.4	4.2	3.9	3.6	23.7	37.4	11.5	1849	59
Pittsburgh.....	40 22	79 59	745	54	3.0	3.5	3.6	4.0	3.4	2.9	20.4	33.5	12.8	1854	56
Philadelphia.....	39 55	75 10	32	72	3.4	3.8	3.8	4.0	4.3	3.5	22.8	41.1	10.3	1881	54
DISTRICT OF COLUMBIA AND MARYLAND.															
Washington.....	38 54	77 03	110	41	3.4	4.1	3.9	4.5	4.0	3.5	23.4	39.9	14.3	1894	55
Baltimore.....	39 17	76 37	68	26	3.4	3.8	4.0	4.7	4.0	3.9	23.8	38.7	15.0	1893	54
Cumberland.....	39 39	78 45	630	24	2.5	3.4	3.8	3.4	3.2	2.8	19.1	29.4	11.0	1885	57
Emmitsburg.....	39 43	77 20	498	12	3.5	4.6	3.0	3.4	3.3	3.8	22.5	33.8	13.5	1845	52
Fallston.....	39 30	76 24	300	25	3.5	4.3	4.1	4.4	4.7	4.5	25.5	42.9	16.1	1881	53
Frederick.....	39 24	77 24	415	15	3.7	4.4	4.6	3.5	2.7	3.7	22.6	31.2	15.0	1854	50
Fort McHenry.....	39 16	76 35	36	45	3.0	3.4	3.4	3.5	4.0	3.4	20.7	42.9	11.5	1855	53
Woodstock College.....	39 19	76 51	820	21	3.2	4.0	3.7	3.7	4.0	4.0	22.6	30.7	11.6	1884	51
VIRGINIA.															
Lynchburg.....	37 22	79 12	523	26	3.3	4.0	3.5	4.1	3.9	3.9	22.7	39.4	12.3	1881	53
Norfolk.....	36 51	76 17	12	26	4.3	4.2	4.4	5.8	6.3	4.7	29.7	43.3	19.9	1884	57
Powhatan Hill.....	38 13	77 12	317	20	2.4	3.4	3.4	3.6	4.5	2.8	20.1	28.0	12.2	1872	61
Prospect Hill Farm.....	37 25	75 52	573	27	3.7	4.0	3.2	4.7	4.6	3.7	23.9	39.3	9.2	1884	51
Wytheville.....	36 55	81 00	2,230	26	3.4	3.7	4.0	4.0	4.0	3.7	22.8	30.7	17.3	1885	55
NORTH CAROLINA.															
Hatteras.....	35 15	75 40	20	22	4.7	4.6	4.6	6.4	6.4	6.4	33.1	52.0	23.7	1887	50
Kittyhawk.....	36 00	75 42	22	18	4.4	3.7	4.6	5.8	6.8	4.6	29.9	47.3	16.0	1893	53
Lenoir.....	35 58	81 30	1,186	25	3.5	4.8	4.1	5.1	5.7	4.6	27.8	39.7	14.8	1881	55
Southport.....	33 55	78 01	34	20	2.8	3.4	3.9	6.8	5.7	5.0	28.2	38.3	20.2	1882	56
Wilmington.....	34 14	77 57	52	26	2.9	4.2	5.7	7.1	7.3	6.3	33.5	56.5	27.0	1882	62
Weldon.....	36 24	77 32	80	24	3.4	4.6	4.0	5.1	5.3	4.0	26.4	39.3	16.5	1881	56
SOUTH CAROLINA.															
Aiken.....	33 32	81 34	520	23	3.4	3.7	4.6	4.9	5.9	3.5	26.0	35.6	16.6	1861	54
Kirkwood.....	34 17	80 33	232	32	3.1	3.6	3.9	5.2	5.3	3.9	25.0	37.9	12.8	1869	57
Charleston.....	32 47	79 56	15	89	2.4	3.6	4.8	6.6	7.2	5.7	30.3	52.0	11.3	1850	62
GEORGIA.															
Atlanta.....	33 45	84 23	1,050	27	4.2	3.6	4.1	3.9	4.5	3.7	24.0	36.3	16.0	1878	48
Augusta.....	33 28	81 54	134	27	3.4	3.4	4.6	5.4	5.0	3.7	25.5	37.4	17.4	1870	53
Forsyth (near).....	33 00	83 55	735	23	3.8	3.3	4.7	4.9	5.7	3.3	25.7	38.5	16.1	1878	48
Quitman (near).....	30 45	83 39	170	15	4.0	3.0	6.6	6.2	5.6	4.1	29.5	38.0	19.8	1886	55
Savannah.....	32 05	81 05	32	48	2.7	3.8	5.8	6.6	7.8	5.2	21.9	53.9	19.0	1881	63
FLORIDA.															
Fort Barrancas.....	30 21	87 18	20	23	4.9	4.6	5.8	8.4	9.9	5.9	39.5	77.4	18.7	1851	56
Fort Brook.....	28 00	82 28	20	24	1.9	2.9	7.6	9.8	9.5	6.2	37.9	73.1	22.7	1857	71
Key West.....	24 33	81 49	27	49	1.2	2.9	4.5	3.8	5.0	6.6	24.0	46.1	12.8	1893	63
Jacksonville.....	30 20	81 39	24	27	2.7	3.8	6.1	6.2	6.7	8.2	33.7	52.3	23.7	1890	62
ALABAMA.															
Greensboro.....	32 41	87 36	220	23	4.0	3.5	3.7	3.6	5.2	3.1	23.1	32.1	13.0	1858	46
Greene Springs.....	32 47	87 43	500	23	6.0	3.8	4.4	4.5	4.6	2.8	26.1	36.3	17.5	1870	48
Mobile.....	30 41	88 02	4	26	4.6	4.3	5.9	6.7	6.8	5.0	33.3	49.6	20.0	1894	53
Montgomery.....	32 23	86 18	162	24	4.8	4.0	4.7	4.6	4.0	2.9	25.0	36.7	18.3	1875	48
Mount Vernon Arsenal.....	31 12	88 02	200	30	4.6	3.9	6.1	6.2	5.9	3.7	30.4	46.6	18.9	1891	49
Union Springs.....	32 12	85 39	485	26	4.4	3.2	3.9	3.8	3.9	2.5	21.7	33.0	10.1	1870	47
MISSISSIPPI.															
Columbus.....	33 31	88 28	208	34	5.8	3.6	4.1	4.7	4.2	3.4	25.8	40.3	14.2	1860	47
Natchez.....	31 34	91 27	206	23	5.2	4.1	4.0	5.1	4.5	3.7	26.6	38.5	16.8	1862	49
Vicksburg.....	33 22	90 53	190	42	5.3	4.4	3.9	4.5	3.4	3.3	24.8	42.6	7.8	1851	47

a Combined with Allegheny Arsenal.

RAINFALL OF THE UNITED STATES.

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TABLE I.—Monthly and seasonal averages of rainfall, etc.—Continued.

Stations.	Latitude.	Longitude.	Elevation.	Number of years.	April.	May.	June.	July.	August.	September.	Total.	Maximum.	Minimum.	Year of minimum rainfall.	Percentage of annual.
LOUISIANA.															
Baton Rouge	30 26	91 11	19	24	4.7	4.5	5.0	6.3	5.9	4.2	30.6	81.9	17.1	1844	51
New Orleans	29 58	90 04	6	26	5.2	4.8	6.7	6.4	6.0	4.6	33.7	49.7	15.2	1891	56
Shreveport	32 30	93 40	183	25	5.2	4.2	3.7	3.4	2.1	3.7	22.3	38.1	13.7	1883	46
ARKANSAS.															
Helena	34 36	90 36	197	21	6.7	4.5	4.7	4.5	3.5	3.9	27.8	53.2	15.0	1881	48
Washington	33 34	93 41	660	28	6.0	5.2	3.9	4.7	3.9	3.1	26.8	40.8	14.6	1851	49
Fort Smith	35 22	94 24	418	33	4.8	4.7	4.2	3.9	3.4	3.1	24.1	37.4	10.4	1856	56
TEXAS.															
Austin	30 16	97 42	480	30	3.0	4.2	2.7	1.8	2.7	4.2	18.6	32.0	9.3	1856	56
El Paso	31 45	106 30	3,697	33	0.1	0.3	0.5	1.6	1.9	1.6	6.0	14.8	1.1	1860	68
Fort Brown	25 52	97 28	165	28	0.7	2.1	1.9	2.1	2.0	5.6	15.3	38.9	3.7	1850	59
Fort Clark	29 14	100 51	1,000	27	1.5	3.2	2.5	1.6	2.5	3.6	14.9	30.0	4.1	1893	66
Fort Duncan	28 38	100 15	800	26	1.1	2.5	2.9	2.1	2.9	3.7	15.2	25.1	4.6	1893	70
Fort McIntosh	27 31	99 32	460	30	1.3	2.3	2.3	1.8	2.8	2.6	13.1	19.2	5.0	1856	64
Galveston	29 17	94 49	3	26	2.8	3.7	4.9	3.1	5.3	6.0	25.8	43.7	9.1	1896	58
San Antonio	29 24	98 29	686	26	2.5	3.0	3.1	2.0	3.6	3.6	17.8	27.2	4.9	1858	59
WEST VIRGINIA.															
Morgantown	39 36	79 59	963	19	3.5	3.6	4.7	5.2	4.6	3.7	25.3	37.2	17.5	1894	54
Wheeling	40 03	80 43	637	12	2.8	4.1	3.7	3.7	4.1	2.8	21.2	36.5	12.9	1894	55
OHIO.															
Cincinnati	39 06	84 30	490	62	3.3	4.0	4.4	3.9	3.8	3.0	22.4	33.3	11.9	1870	53
Cleveland	41 30	81 42	582	41	2.7	3.5	3.9	3.4	3.1	3.6	20.2	31.4	12.5	1895	55
Marietta	39 30	81 26	611	69	3.3	3.9	4.1	4.4	3.9	3.1	22.7	38.3	14.5	1894	54
North Lewisburg	40 11	83 35	1,030	25	3.1	3.9	4.0	4.4	3.3	3.2	21.9	33.5	10.2	1895	54
Portsmouth	38 48	83 03	528	64	3.2	3.5	4.0	3.9	3.4	2.8	20.8	33.1	9.7	1834	51
Steubenville	40 25	80 41	663	39	3.4	3.9	4.0	4.0	3.9	3.5	22.7	33.7	13.5	1854	55
Toledo	41 40	83 24	579	26	2.2	3.4	3.4	3.1	2.7	2.4	17.2	26.5	10.2	1893	55
Wauseon	41 36	84 07	767	23	3.0	4.2	4.1	3.4	2.7	2.6	20.0	35.2	10.2	1895	54
KENTUCKY.															
Louisville ^b	38 15	85 45	432	54	4.2	4.1	4.7	4.1	3.8	3.0	23.9	37.0	14.6	1881	51
Newport Barracks	39 06	84 29	515	24	3.3	4.1	4.2	4.3	3.5	3.4	22.8	40.2	10.5	1870	57
TENNESSEE.															
Austin	36 12	87 10	568	17	4.8	3.4	5.1	4.0	3.7	3.8	24.8	34.2	13.3	1887	48
Glenwood Cottage ^c	36 28	87 20	394	30	4.9	3.8	4.1	3.7	3.5	2.9	22.9	33.6	16.3	1860	48
Knoxville	35 56	83 58	900	26	4.9	4.0	4.2	4.4	4.0	2.7	24.2	38.2	15.6	1894	48
Memphis	35 09	90 03	245	26	5.4	4.4	4.6	3.4	3.5	3.1	24.4	49.2	12.8	1887	46
Nashville	36 10	86 47	435	32	4.7	3.9	4.3	4.3	3.6	4.1	24.9	29.8	15.4	1871	50
Chattanooga	35 04	85 15	783	18	4.5	4.1	4.7	4.1	4.1	3.7	25.2	37.3	13.6	1894	47
INDIANA.															
Evansville	38 02	87 29	386	18	4.5	4.4	4.5	3.6	3.8	3.3	24.1	33.8	15.1	1887	51
Indianapolis	39 40	86 10	722	27	3.6	4.0	4.5	4.2	3.3	3.1	22.7	36.7	10.9	1870	54
Lacoma	38 05	86 07	530	23	3.8	3.8	4.3	3.3	3.2	2.9	21.3	31.5	13.6	1874	49
Logansport	40 43	86 22	586	19	3.5	5.0	4.2	2.9	2.9	3.1	21.6	33.8	11.0	1895	55
New Harmony	38 10	87 54	350	25	3.4	3.7	3.9	3.8	3.4	3.2	21.4	30.8	10.4	1871	54
Richmond	39 51	84 53	968	22	3.6	4.3	3.9	3.5	3.9	4.1	23.3	38.0	10.4	1856	55
Spiceland	39 48	85 18	1,063	28	2.9	3.8	4.4	4.1	3.3	3.1	21.6	38.2	11.1	1871	54
Vevay	38 46	84 59	525	31	3.7	4.0	4.9	3.8	3.2	3.2	22.8	33.1	12.4	1895	53
ILLINOIS.															
Augusta	40 12	90 57	674	19	4.0	4.1	4.1	4.8	3.6	4.1	24.7	30.7	14.8	1857	63
Aurora	41 47	88 08	648	22	3.2	4.0	3.8	3.3	3.4	3.2	20.9	35.5	14.8	1887	56
Cairo	37 00	89 10	313	25	3.8	4.1	4.4	3.4	2.8	2.6	21.1	29.6	10.0	1887	49
Chicago	41 52	87 38	589	30	3.0	3.7	3.7	3.4	2.9	3.0	19.7	29.1	11.9	1887	58
Golconda	37 23	88 30	18	3.8	4.3	4.4	3.4	3.2	3.2	3.2	22.3	39.1	14.2	1869	50
Marengo	42 15	88 37	819	45	2.8	3.9	4.3	3.7	3.7	3.8	22.2	43.1	12.0	1863	63
Mattoon	39 29	88 24	737	15	4.2	5.0	4.8	3.9	3.4	2.9	24.2	36.8	15.1	1881	57
Ottawa	41 22	88 48	688	25	2.9	4.0	3.6	3.6	2.9	2.9	19.9	37.3	9.7	1887	50
Peoria	40 42	89 36	452	41	3.2	3.8	3.7	4.0	3.0	3.5	21.2	34.9	10.4	1870	61
Rockford	42 15	89 05	730	22	3.3	4.0	4.8	3.6	3.2	2.4	21.3	41.2	13.8	1874	59
Sandwich	41 31	88 32	656	17	3.7	4.6	4.3	4.5	4.5	3.5	25.1	36.5	10.6	1877	59
Winnebago	42 17	89 12	861	18	3.2	4.0	4.1	3.5	3.2	3.6	21.6	33.8	14.4	1859	63
IOWA.															
Amasa	41 47	91 55	.....	21	2.6	4.1	4.8	3.9	3.5	3.4	22.3	32.3	9.7	1886	67
Anes	42 00	93 38	926	21	2.9	4.1	4.4	4.7	3.4	3.6	23.1	38.7	13.0	1886	74
Brookville	41 04	92 05	.....	17	3.1	4.0	4.6	3.9	3.5	3.1	22.2	41.3	9.7	1863	68
Clinton	41 50	90 10	593	22	3.1	4.7	4.7	3.9	3.8	3.3	23.0	34.6	13.9	1886	63
Cresco	43 32	92 10	1,300	25	2.6	3.8	5.0	3.9	2.8	3.6	21.7	30.1	12.0	1877	70
Davenport	41 30	90 39	595	26	2.8	4.2	4.2	3.6	3.6	3.2	21.6	32.8	10.9	1894	65
Dubuque	42 30	90 40	611	27	2.6	3.7	4.6	4.2	3.2	4.1	22.4	39.1	10.6	1894	65
Fort Madison	40 37	91 28	522	43	3.2	4.3	4.4	3.8	3.7	3.7	23.1	37.6	13.7	1857	63
Independence	42 29	91 57	915	27	2.2	4.1	4.9	4.4	3.3	4.3	23.2	42.3	11.0	1894	72
Iowa City	41 37	91 30	667	33	3.0	4.3	4.7	4.4	4.4	4.0	24.8	41.3	10.5	1886	65
Keokuk	40 25	91 21	505	25	3.2	4.1	4.5	4.1	2.8	3.5	22.2	37.9	13.0	1887	64
Logan	41 00	95 00	.....	27	2.7	4.4	5.6	5.0	3.9	3.2	24.8	40.7	16.7	1894	73
Monticello	42 15	91 15	880	42	2.6	3.9	4.5	4.2	3.7	3.8	22.7	39.3	10.2	1871	63
Mount Pleasant	40 59	91 37	729	16	2.5	4.5	5.8	3.1	3.2	2.8	21.9	33.5	11.1	1890	67
Muscatine	41 26	91 05	562	48	3.5	4.4	4.8	3.8	4.2	3.7	24.4	45.6	11.1	1863	63
Oskaloosa	41 18	92 36	843	13	2.6	3.6	4.4	3.4	2.8	3.3	20.1	30.6	9.8	1890	69

^a Camp Eagle Pass.

^b Combined with Springdale.

^c Clarksville.

^d Probably a n over-measurement.

RAINFALL OF THE UNITED STATES.

TABLE I.—Monthly and seasonal averages of rainfall, etc.—Continued.

Stations.	Latitude.	Longitude.	Elevation.	Number of years.	April.	May.	June.	July.	August.	September.	Total.	Maximum.	Minimum.	Year of minimum rainfall.	Percentage of annual
MISSOURI.															
Hermann.....	38 41	91 27	480	21	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	1883	60
Miami.....	39 18	93 15	640	49	3.0	4.2	5.0	4.2	3.6	3.4	23.4	42.4	8.1	1860	65
Oregon.....	39 59	95 09	1,100	41	3.3	4.7	4.7	4.3	4.3	3.1	24.4	36.8	12.7	1894	68
St. Louis.....	38 38	90 12	431	60	3.7	4.7	5.0	3.8	3.5	3.1	23.8	31.2	10.7	1871	58
INDIAN TERRITORY AND OKLAHOMA.															
Fort Gibson.....	35 50	95 20	510	29	4.1	4.5	3.9	2.7	2.8	2.7	20.7	34.7	9.7	1838	58
Fort Sill.....	34 40	98 23	1,190	24	2.7	4.4	3.7	2.9	3.2	2.8	19.7	31.3	8.0	1896	66
MICHIGAN.															
Alpena.....	45 05	83 30	609	24	2.2	3.5	3.7	2.9	3.5	3.8	19.6	30.3	12.6	1895	56
Detroit.....	42 20	83 03	580	46	2.6	3.1	3.8	3.6	2.6	3.0	18.7	31.0	10.9	1895	58
Grand Haven.....	43 05	86 18	592	25	2.6	3.4	3.8	2.8	2.7	3.6	18.9	30.5	10.6	1891	55
Grand Rapids.....	42 57	85 40	604	14	2.8	3.6	4.2	2.4	2.7	3.4	18.8	28.3	11.3	1895	55
Kalamazoo.....	42 20	85 38	770	20	2.6	4.4	4.5	3.2	2.6	3.2	20.5	28.6	15.0	1895	57
Lansing.....	42 44	84 32	836	33	2.4	3.4	4.0	3.1	2.7	2.9	18.5	32.8	12.9	1887	59
Fort Huron.....	43 00	82 26	584	22	2.1	3.4	3.5	2.4	2.6	2.6	16.6	25.1	8.8	1899	53
MINNESOTA.															
Fort Ripley.....	46 10	94 24	1,169	27	1.8	3.2	4.3	4.0	3.3	3.1	19.7	28.3	8.6	1864	73
Fort Snelling.....	44 53	93 10	722	44	2.3	3.2	3.9	3.4	3.1	3.3	19.2	35.3	11.6	1852	74
Minneapolis.....	44 58	93 15	810	29	2.5	3.5	4.1	3.2	3.7	3.4	20.4	33.4	10.8	1894	69
St. Paul.....	44 58	93 03	703	39	2.5	3.5	4.1	3.3	3.8	3.2	20.4	28.1	12.2	1882	72
WISCONSIN.															
Beloit.....	42 30	89 11	741	30	2.9	3.2	4.0	3.5	3.6	3.4	20.6	35.2	10.9	1870	62
Embarras.....	44 25	88 38	796	29	2.6	3.7	5.3	4.5	4.9	4.1	25.1	39.0	15.7	1867	62
La Crosse.....	43 49	91 15	657	24	2.4	3.3	4.5	4.0	3.2	4.2	21.6	32.1	11.8	1887	70
Madison.....	43 05	89 24	857	28	2.6	3.5	4.5	4.0	3.1	3.1	20.8	35.5	7.9	1895	63
Manitowoc.....	44 07	87 46	593	33	2.4	2.6	3.6	3.5	3.2	3.0	18.3	29.6	11.5	1891	59
Milwaukee.....	43 02	87 54	591	53	2.8	3.4	3.8	3.2	2.7	3.0	18.9	29.7	12.6	1847	61
NORTH DAKOTA.															
Bismarck.....	46 47	100 38	1,670	22	2.3	2.5	3.5	2.3	2.0	1.2	13.8	23.4	7.7	1889	75
Fort Buford.....	48 01	103 58	1,855	29	1.2	2.4	2.8	1.7	1.2	0.8	10.1	17.8	4.4	1871	73
St. Vincent ^b	48 56	97 10	789	24	1.5	2.5	3.9	2.6	2.6	1.7	14.8	23.4	8.5	1889	76
Fort Totten.....	47 59	98 57	1,565	21	1.4	2.3	3.7	2.4	2.5	1.0	13.3	17.7	8.3	1883	75
SOUTH DAKOTA.															
Fort Meade.....	44 26	103 28	3,624	16	3.8	3.5	3.3	1.9	1.7	0.6	13.8	20.3	8.9	1893	74
Fort Randall.....	43 04	98 42	1,236	32	1.9	3.4	3.3	2.7	2.6	1.9	15.8	24.3	5.3	1863	75
Fort Sully.....	44 39	100 39	1,688	25	2.1	2.6	3.3	2.7	1.9	0.9	13.5	21.4	7.5	1894	78
Fort Wadsworth.....	45 43	97 40	2,000	18	2.0	3.0	3.7	3.4	2.7	1.3	16.1	25.1	7.8	1871	77
Yankton.....	42 56	98 23	1,206	20	3.3	4.0	4.1	3.5	3.0	2.6	20.5	32.3	11.3	1894	79
NEBRASKA.															
De Soto.....	41 28	96 03	1,100	24	2.6	4.5	4.6	4.3	3.3	3.3	22.6	39.5	13.0	1886	68
Genoa.....	41 26	97 43	1,585	31	2.9	4.1	4.5	3.9	2.5	2.8	20.7	30.1	11.1	1894	77
North Platte.....	41 08	100 45	2,809	29	2.1	3.0	3.5	2.5	2.3	1.5	14.9	21.7	8.0	1869	82
Omaha.....	41 16	95 56	1,040	27	3.1	4.5	5.3	4.6	3.3	3.0	23.8	39.9	11.1	1894	76
KANSAS.															
Dodge City.....	37 45	100 01	2,477	22	1.8	3.1	3.3	3.2	2.8	1.3	15.5	27.6	9.0	1893	78
Independence.....	37 13	95 41	798	25	3.7	4.6	4.9	4.2	3.0	3.7	24.1	36.4	16.9	1890	66
Lawrence.....	38 58	95 14	829	31	3.2	4.6	5.0	4.7	3.9	3.5	24.9	38.6	15.7	1886	69
Leavenworth.....	39 19	94 57	770	57	2.9	4.4	5.4	4.0	4.1	3.6	24.4	42.6	9.3	1864	70
Manhattan.....	39 12	96 37	1,014	35	2.6	4.1	4.5	4.7	3.6	3.0	22.5	36.4	10.2	1860	75
Fort Riley.....	39 02	96 45	1,074	40	2.0	3.4	3.9	3.7	3.7	2.8	19.5	31.0	9.7	1860	76
Topeka.....	39 03	95 39	886	18	2.9	4.8	5.2	4.7	4.0	3.1	24.7	36.7	14.8	1886	72
Wallace.....	38 54	101 35	3,303	18	1.6	2.8	2.3	3.4	1.7	1.3	13.1	31.8	6.4	1873	83
MONTANA.															
Fort Assinaboine ^c	48 36	109 45	2,576	16	1.0	1.7	3.1	2.1	1.4	1.2	10.5	22.9	5.2	1883	74
Helena.....	46 33	112 04	3,932	19	1.1	1.6	2.3	1.1	0.6	1.2	7.9	13.0	3.8	1889	60
Fort Keogh.....	46 22	105 56	2,367	15	1.1	2.2	2.8	1.2	0.9	0.8	9.0	18.3	5.6	1894	71
WYOMING.															
Cheyenne.....	41 08	104 48	6,064	27	1.5	2.3	1.5	1.9	1.6	1.0	9.8	17.3	3.9	1876	77
Laramie.....	42 14	104 25	7,159	21	1.3	2.6	1.4	1.5	1.2	0.9	8.9	29.0	1.3	1863	72
Fort Bridger.....	41 28	110 30	6,753	17	0.9	1.0	0.5	0.5	0.9	0.5	4.3	7.2	1.8	1871	46
IDAHO.															
Boise City.....	43 37	116 00	2,768	27	1.3	1.6	0.8	0.2	0.2	0.4	4.5	9.1	2.0	1881	32
Fort Lapwai.....	46 18	116 54	2,000	12	1.3	1.8	1.5	0.4	0.6	0.8	6.4	10.6	2.4	1872	39
UTAH.															
Corinne.....	41 30	112 18	4,232	23	1.1	1.1	0.6	0.4	0.3	0.6	4.1	8.7	2.0	1877	35
Camp Douglas.....	40 46	111 50	5,024	23	2.0	2.4	0.7	0.8	0.7	0.7	7.3	14.4	3.2	1865	43
Ogden.....	41 12	111 57	4,307	23	1.5	1.5	0.6	0.2	0.4	0.7	4.9	9.9	0.5	1881	35
Promontory.....	41 35	112 35	4,905	27	0.8	0.8	0.5	0.2	0.4	0.7	3.4	9.0	0.3	1890	41
Salt Lake City.....	40 46	111 54	4,262	29	2.0	2.0	1.1	0.9	1.3	1.0	8.3	23.3	2.2	1890	44
Terrace.....	41 30	113 30	4,544	22	0.4	0.6	0.2	0.1	0.1	0.3	1.7	4.8	0.0	1882	40

^a Also Williston.^b Pembina, N. Dak., and St. Vincent, Minn., combined.^c Havre.

Chart II.

Normal Rainfall of the United States east of the 100th meridian, April to September, inclusive.

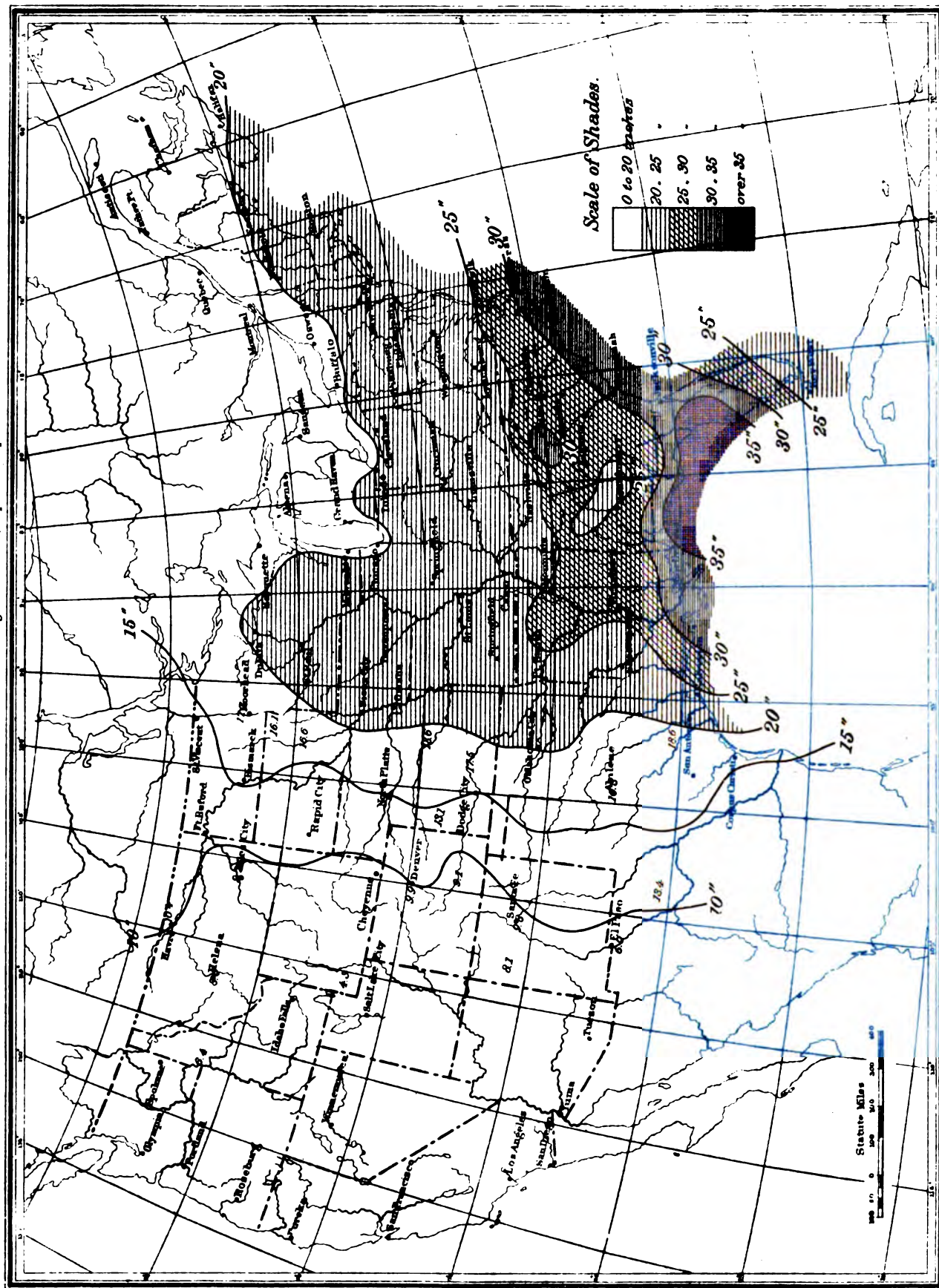


TABLE I.—*Monthly and seasonal averages of rainfall, etc.*—Continued.

Stations.	Latitude.	Longitude.	Elevation.	Number of years.	April.	May.	June.	July.	August.	September.	Total.	Maximum.	Minimum.	Year of minimum rainfall.	Percentage of annual.
NEW MEXICO.															
Santa Fe.....	35 42	106 01	6,939	37	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.		
Fort Stanton.....	33 29	105 31	6,151	19	0.7	0.9	1.1	2.7	2.7	1.6	9.7	18.4	4.6	1889	66
Fort Wingate.....	35 28	108 32	7,038	30	0.6	1.0	1.7	3.2	3.8	2.1	12.4	22.8	5.4	1892	69
					0.9	0.5	0.6	2.4	2.3	1.3	8.0	14.2	1.7	1892	55
COLORADO.															
Colorado Springs.....	38 51	104 46	5,978	12	1.4	2.4	1.9	3.2	2.2	1.1	12.2	16.7	7.1	1888	84
Denver.....	39 45	105 00	5,182	27	2.0	2.7	1.3	1.7	1.4	0.9	10.0	14.7	5.6	1871	70
Fort Garland.....	37 25	105 23	7,921	20	1.1	1.0	1.2	2.4	2.0	1.1	8.8	33.6	1.4	1883	70
Fort Lyon.....	38 06	103 30	3,910	17	1.0	1.8	1.4	2.2	1.8	0.9	9.1	15.8	4.3	1871	77

Average distribution for the crop season.—The averages for the crop-growing season and the absolute amount of rain that fell in the season of least rainfall are also graphically shown on Charts II and III, respectively. The particular significance of these figures and charts lies in the fact that they broadly outline the areas in the United States east of the Rocky Mountains that are adapted to agricultural operations without irrigation. The exact amount of rainfall required for the successful cultivation of crops has not been fixed nor can be in terms of rainfall alone. On the Pacific Coast and over comparatively small areas in the arid regions wheat and other cereals are grown with a seasonal rainfall considerably less than 15 inches, but it should be remembered that the climatic conditions, as regards temperature and humidity, are quite different from those which obtain in the wheat region of the Northwest. The character of the soil, especially as regards its ability to retain moisture, is a very important consideration. It is said, in explanation of the fact that wheat is grown in eastern Washington, where the *yearly* fall is generally under 18 inches, that the rainfall of winter and early spring is conserved in the soil and is supplied to the plant by capillary action during the early part of the growing season.

The average rainfall of Spokane, in the wheat region of eastern Washington, during April, May, and June, is but 4.5 inches, or about as much as falls in a single month in the wheat region of the Mississippi Valley. It is quite obvious that the growth of the plant is not due to the rainfall of the spring and early summer months alone.

A comparison of the seasonal precipitation chart with the returns of the Eleventh Census confirms the view above expressed, viz, that the area devoted to the cultivation of cereals can be broadly defined by the line of 15 inches, or nearly that amount of rain, per season, although no hard and fast rule can be laid down. The valley of the Red River of the North is widely known as a famous wheat-producing region; yet the seasonal rainfall from St. Vincent northward is a little under 15 inches.

Least rainfall during crop season.—The chart of least rainfall is intended to show the smallest amount of rain that has ever been recorded between April 1 and September 30. The registers from which the chart was prepared are not wholly synchronous, and therefore the results do not always accord as closely as might be wished. Nevertheless, it is worthy of note that the least rainfall at stations whose records extend over forty or fifty years is not greatly below the extreme recorded in half the time. There seems to be a fairly constant ratio between the least rainfall and the mean fall of any place; thus, in California the fall in the year of least rain is generally 50 per cent of the mean. In the present case, those stations east of the Alleghanies having an average fall for the season of 20 inches, generally, have not less than 11 or 12 inches, or about 60 per cent, in the year of least rainfall. West of the Alleghanies the ratio is a little less, the fall of the driest year being about 55 per cent of the seasonal average.

The ratio of the rainfall of the crop season to the total of the year.—This varies still more widely. On the plains 70 per cent and upward of the yearly fall comes in the growing months of the year; elsewhere the ratio is less, being a little over 50 per cent east of the Mississippi River.

As might be expected, the years of least rainfall are not distributed evenly throughout the whole observational period. No very useful deductions can be made from the whole mass of data, since a common period of time is not covered by all the registers. Of the whole number used,

however, 81 cover the period 1871-1896, and of these 49 extend over varying periods of time preceding 1871. Some interesting facts may be drawn from these registers.

Periods of drought.—The years of minimum rainfall or drought from 1871 to 1896 fall in groups, separated by irregular time intervals. The first group centers about 1871; the second, 1881; the third, 1887; and the last, 1894-95. The drought of 1887 was severe in some months, but not consistently so throughout the entire season; the droughts of 1881 and 1894 were widespread and severe. The former was confined principally to States east of the Alleghanies, while the latter was felt from Nebraska eastward to Massachusetts and southward to Alabama. Prior to 1870 the few records available indicate a local drought in Kansas and western Missouri in 1860, more severe than has since been experienced. Widespread drought in the central valleys and Lake region also occurred in 1863. The periods of extensive drought in chronological order are, therefore, 1860, 1863, 1870-71, 1881, 1887, and 1894-95. There have been, of course, severe local droughts in various portions of the United States during the intervening years, as there must always be in a territory of such vast extent.

In order to determine how closely the least seasonal rainfall of the period 1871-1896 approaches the lowest ever recorded, an examination was made of the group of 49 stations whose registers extend over earlier years as well as the period 1871-1896.

The table below shows the minima of the two periods at the points having the longest records:

TABLE II.—*Least rainfall April to September, inclusive, at the stations named (inches and tenths).*

Stations.	1871-1896.	Previous years.	Continuous record from—
New Bedford, Mass.	13.2 in 1891	11.6 in 1849	1814
Boston, Mass.	13.9 in 1887	11.8 in 1836	1818
Providence, R. I.	16.3 in 1894	11.3 in 1836	1822
Amherst, Mass.	13.9 in 1887	11.8 in 1836	1836
New York, N. Y.	12.7 in 1881	12.5 in 1849	1836
Newark, N. J.	12.1 in 1881	16.4 in 1845	1844
Philadelphia, Pa.	10.3 in 1881	14.5 in 1825	1825
Washington, D. C.	14.4 in 1894	16.7 in 1809	1856
Savannah, Ga.	19.0 in 1881	20.8 in 1857	a 1837
Portsmouth, Ohio.	12.8 in 1878	9.7 in 1834	b 1830
Cincinnati, Ohio.	12.6 in 1895	11.9 in 1870	1835
Louisville, Ky.	14.6 in 1881	15.4 in 1856	c 1842
St. Louis, Mo.	10.7 in 1871	15.8 in 1870	1837
Miami, Mo.	13.3 in 1871	8.1 in 1860	1847
Monticello, Iowa.	10.2 in 1871	12.4 in 1863	1855
Fort Riley, Kans.	11.1 in 1875	9.7 in 1860	1854
Average	13.2	13.2	

a 1830 1859-1868, inclusive, and 1870 missing.

b 1856, 1857, and 1858 missing.

c 1860 missing.

As will be seen by the above, the year of least rainfall occurred prior to 1871 in nine cases, and either with or subsequent to 1871 in the remaining seven cases. The two principles illustrated by these facts are that intense droughts are not general in extent of territory covered, and that for all practical purposes the least rainfall may be expected to occur within a twenty-five-year period.

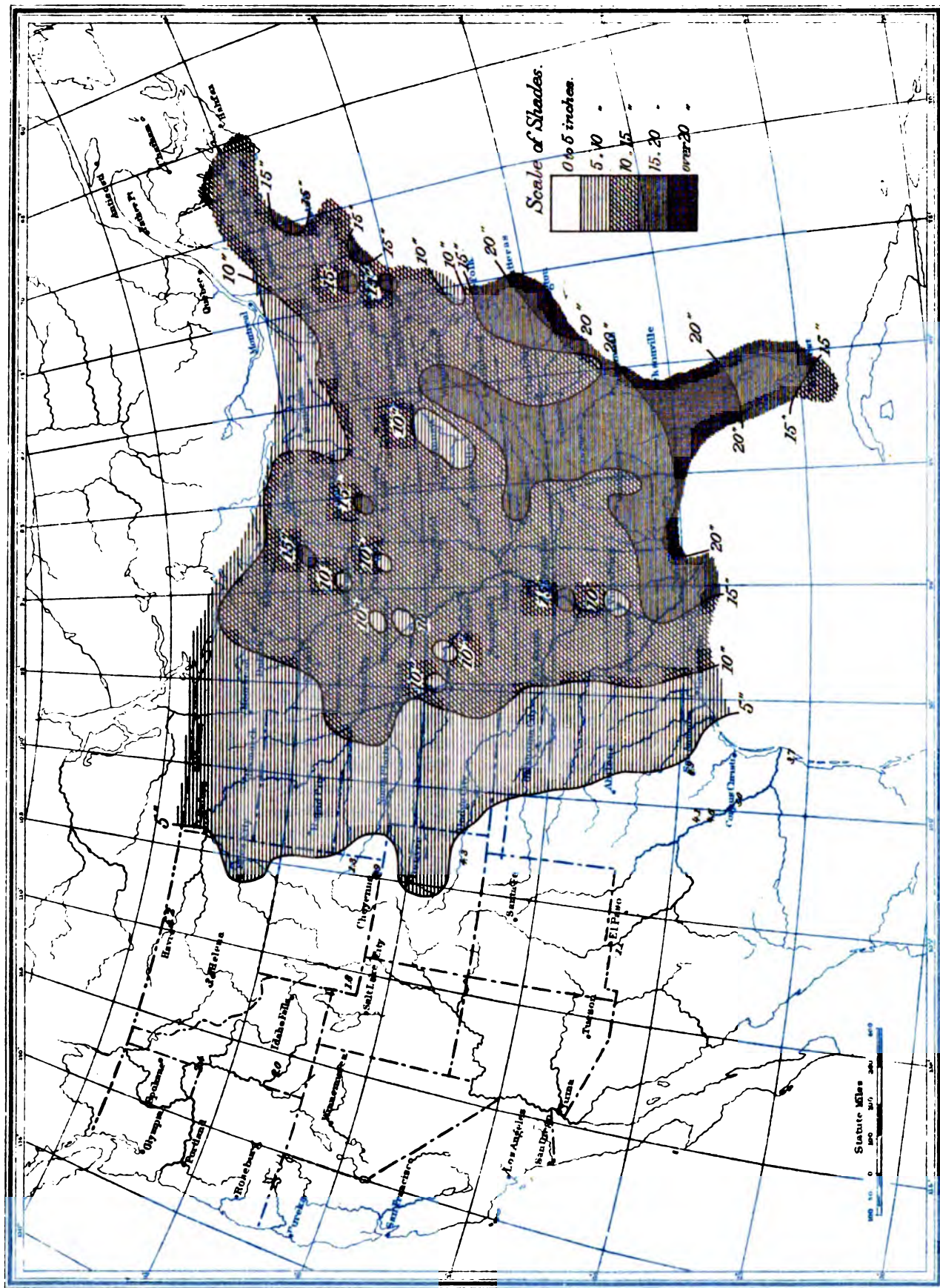
V.—SECULAR VARIATION.

The question of secular variation of rainfall, touched upon on page 10, is not only intensely interesting in its physical aspect, but also of very great economic importance. It is not surprising, therefore, that it should have been the subject of extended investigation at the hands of rainfall students in many parts of the world. The literature of the subject is very extensive, and much ingenuity has been displayed in the search for cycles or periods of recurrent phenomena. It is true that suggestions of a faint periodicity have been found in some regions of the globe, but it is still the general belief that the vicissitudes of rainfall, if not wholly fortuitous, are so intermingled with the variations of pressure, temperature, etc., that no satisfactory solution of the problem will be reached until the greater problem of the general circulation of the atmosphere has been solved.

The local distribution of rainfall is exceedingly erratic. Thus, the catch of two gauges, having practically the same exposure and but a few miles apart, may differ as much as 10 or 15 inches in the total of the year, due solely to the occurrence of a few more thunderstorms at one station than at the other. Individual registers, therefore, often afford doubtful and conflicting information

Least Rainfall, April to September, inclusive.

Chart III.



respecting the yearly fall of one and the same region. But if we group the rainfall registers of an entire district, the combined result will generally show whether the fall of the year is abnormal and to what extent.

The table below was formed by computing the departure from the normal of the actual annual rainfall at each of the various stations in the several geographic districts. The annual departures were then added algebraically and the average of the sum obtained. Thus, in New England in 1887 the algebraic sum of the annual departures was $+21.6 \text{ inches} \div 9 = +2.4 \text{ inches}$ as given below:

TABLE III.—Departures from the normal precipitation by geographic districts during the ten years 1887–1896.

Districts.	Number of stations.											Years.	
		1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	Above.	Below.
		<i>Inches.</i>	<i>Inches.</i>	<i>Inches.</i>	<i>Inches.</i>	<i>Inches.</i>	<i>Inches.</i>	<i>Inches.</i>	<i>Inches.</i>	<i>Inches.</i>	<i>Inches.</i>		
New England.....	9	+2.4	+10.1	+5.2	+5.8	+0.3	-4.8	-0.8	-7.5	-2.8	-5.0	5	5
Middle Atlantic States.....	11	-1.0	+4.7	+12.0	+5.4	+4.5	-2.3	+2.9	-2.5	-7.6	-7.2	5	5
South Atlantic States.....	11	-1.5	+0.2	+2.0	-5.0	-1.7	-7.4	+1.5	-2.0	-1.5	-10.7	3	7
Eastern Gulf States.....	5	-6.0	+7.2	-6.7	-5.0	-0.2	-7.0	-1.2	-6.9	-6.4	-9.0	1	9
Western Gulf States.....	8	-6.1	+8.3	-2.2	+2.1	-9.1	-3.8	-9.3	-4.6	-3.6	-12.5	2	8
Ohio Valley and Tennessee.....	11	-4.2	+1.9	-4.3	+9.2	+0.3	-1.9	-2.6	-8.9	-11.6	-4.6	3	7
Lower Lake region.....	8	-3.9	-4.8	-2.4	+5.2	-3.6	+3.8	-0.3	-3.8	-5.5	+0.1	3	7
Upper Lake region.....	10	-3.1	-5.0	-3.6	-0.1	-2.4	-0.8	+0.7	-2.4	-5.4	-4.6	1	9
Extreme Northwest.....	4	-1.0	-2.9	-6.3	-0.4	+3.9	-1.0	-0.9	-0.4	-1.1	+2.9	2	8
Upper Mississippi Valley.....	13	-4.9	-0.6	-6.1	+0.1	-5.1	+4.7	-3.4	-8.7	-9.2	+0.5	3	7
Missouri Valley.....	10	-2.2	-2.3	-4.1	-4.1	+0.9	+2.0	-2.1	-8.0	-0.6	+0.2	3	7
Northern Slope.....	6	+1.1	0.0	-2.4	-2.7	+4.5	+1.8	-1.1	-1.2	-1.0	+0.9	4	5
Southern Slope.....	4	+1.3	+3.7	-2.4	+1.8	-0.8	+2.2	-5.2	-3.4	+4.0	+1.0	6	4
Middle Slope.....	7	-4.2	-4.5	-0.3	-4.2	+6.0	+1.8	-5.4	-5.1	+0.6	-1.8	3	7
Southern Plateau.....	9	+0.9	+0.2	-1.4	+1.0	-2.1	-4.7	-1.7	-2.7	+0.2	+1.1	5	5
Middle Plateau.....	5	-3.9	-1.7	+1.9	-0.4	+2.0	-0.6	+0.4	+0.7	-2.8	+2.4	5	5
Northern Plateau.....	4	-2.1	-4.5	-4.1	-4.1	-0.8	0.0	+6.2	+3.2	-3.0	+1.1	3	6
North Pacific Coast.....	8	-6.2	-6.6	-10.6	-9.0	+8.4	-3.0	+13.3	+11.8	+5.8	+10.1	5	5
California.....	12	-5.6	-1.8	+11.4	+1.9	-3.4	+4.4	+1.0	+0.6	-1.1	+1.0	6	4
Above the mean.....	4	8	5	9	9	7	7	4	4	11			
Below the mean.....	15	10	14	10	10	11	12	15	15	8			

It appears beyond question that there has been a very general deficiency of rain in the great majority of the years and in almost all of the districts. Moreover, there does not seem to be any law of compensation by which a deficit in one district is balanced by a surplus in another. The South Atlantic and Gulf States, in particular, show a marked deficit throughout almost the entire period. This fact naturally suggests an inquiry into the rainfall of the preceding ten years. The following statement shows the average precipitation at the principal Weather Bureau stations in the region just mentioned for twenty consecutive years in periods of ten years each:

Average annual precipitation in periods of ten consecutive years, 1877–1886 and 1887–1896.

Stations.	Average 1877–1886.	1877–1886.	1887–1896.	Difference.	Stations.	Average 1877–1886.	1877–1886.	1887–1896.	Difference.
	<i>Inches.</i>	<i>Inches.</i>	<i>Inches.</i>	<i>Inches.</i>		<i>Inches.</i>	<i>Inches.</i>	<i>Inches.</i>	<i>Inches.</i>
Lenoir, N. C.....	50.09	51.40	48.78	-2.62	Mobile, Ala.....	62.67	66.61	58.73	-7.88
Hatteras, N. C.....	65.58	73.41	57.76	-15.65	Montgomery, Ala.....	50.97	52.04	49.90	-2.14
Wilmington, N. C.....	53.06	58.83	47.30	-11.53	Vicksburg, Miss.....	54.37	62.04	46.69	-15.35
Charleston, S. C.....	54.59	56.82	52.37	-4.45	Memphis, Tenn.....	52.77	56.76	48.78	-7.98
Augusta, Ga.....	46.09	46.53	47.44	+0.91	New Orleans, La.....	58.81	61.34	54.28	-7.06
Savannah, Ga.....	49.83	50.91	48.75	-2.16	Shreveport, La.....	47.34	54.28	40.42	-13.84
Jacksonville, Fla.....	53.40	57.69	49.12	-8.57	Galveston, Tex.....	46.18	52.40	39.96	-12.44

The facts presented above may be viewed from either of two standpoints: (1) The rainfall of the first period was abnormally high and the apparent decrease noted in the second period is merely a return to normal conditions; or (2) there has been a permanent decrease in the rainfall. The first proposition seems to be the more rational one. The heavy rainfall on the Texas coast, where there is a marked deficiency, is largely due to the advent of cyclonic storms from the Gulf which often have a very slow movement and give torrential rainfall for several days in succession. Thus, 8.70 inches fell on September 16–17, 1877; 8.40 inches on October 24, 1877; 8.24 inches on September 3–4, 1885; 16.53 inches on September 15–20, 1885. In the last-named case the rainfall at points less than 100 miles inland was not a fifth of the fall at Galveston, on the coast.

The movement of these storms, after passing several hundred miles northward, is much accelerated and less rain is precipitated than on and near the coast.

The seaward margin of the South Atlantic States is in the region of West India hurricanes, and naturally receives a greater amount of rainfall in years when these storms are prevalent. While these facts may partially explain the marked variation in the rainfall of individual years, they by no means fully account for the phenomenon in all of its phases.

Although the droughty conditions were nowhere so intense as in portions of the South Atlantic and Gulf States, yet the rainfall of the United States, as a whole, for the ten years 1887-1896 was below the average of the ten years next preceding. This interesting fact naturally suggested an inquiry into the rainfall of the period prior to 1877. Unfortunately the continuous registers available for such purpose are so few and so widely separated that no general comparison can be made. But it is possible to determine with some accuracy the average annual fall for a number of consecutive years prior to the beginning of Signal Service observations in comparatively small areas of the older States, as in New England, the Ohio Valley, and the middle Mississippi Valley.

For obvious reasons a single register does not always truly indicate the rainfall of the district in which it may be situated, but when there is reasonable agreement among three or more registers in the same district it may be assumed that the average of the three affords a close approximation to the true fall. Using three or more registers, we have determined what Blandford has termed progressive averages of precipitation for southeastern New England for each year of the period 1834-1896, the upper Ohio Valley for the same period, and the middle Mississippi Valley, 1858-1896. The stations used and the yearly averages are given in the table following:

TABLE IV.—*Progressive averages of precipitation.*

Southeastern New England: Boston, New Bedford, and Providence.

Upper Ohio Valley: Marietta, Portsmouth, and Cincinnati.

Middle Mississippi Valley: Muscatine, Monticello, Marengo, and Peoria.

$$\frac{(a + 4b + 6c + 4d + e)}{16} = c'$$

Where c' = progressive average of the middle year of the group.

Years.	Southeastern New England.				Upper Ohio Valley.				Middle Mississippi Valley.				
	Boston.	New Bedford.	Providence.	Mean.	Marietta.	Portsmouth.	Cincinnati.	Mean.	Muscatine.	Monticello.	Marengo.	Peoria.	Mean.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
1816		38.1		38.1									
1817		37.8		37.8									
1818		36.7		36.7									
1819		36.4		36.4									
1820	39.0	37.3		38.2									
1821	36.7	39.2		38.0									
1822	36.0	42.2		39.1									
1823	37.5	44.3		40.9									
1824	37.4	42.9		40.2									
1825	37.4	43.3		39.8									
1826	40.0	45.5		42.8									
1827	41.7	47.6		44.6									
1828	41.4	48.1		44.8									
1829	42.6	51.7		47.2									
1830	45.6	54.6		50.0	43.3			43.3					
1831	47.0	51.7		49.4	46.4			46.4					
1832	45.0	45.6		45.3	46.1	40.3		43.2					
1833	41.3	41.2		41.2	42.0	36.7		39.4					
1834	39.2	40.1	30.8	38.7	39.1	31.4		35.2					
1835	38.7	39.8	35.6	38.0	39.1	29.9		34.5					
1836	38.3	38.2	34.8	37.1	39.7	33.9		36.8					
1837	38.4	36.2	35.0	36.5	39.2	38.0	45.4	40.9					
1838	40.3	36.5	36.3	37.7	37.2	37.0		38.0					
1839	43.4	39.4	38.5	40.4	36.4	35.5		36.8					
1840	45.6	42.0	41.4	43.0	38.4	38.6	40.7	39.2					
1841	45.2	42.0	42.6	43.3	41.0	42.7	42.7	42.1					
1842	43.5	40.7	41.5	41.9	41.6	44.8	44.2	43.5					
1843	42.5	40.2	39.8	40.8	40.1	44.3	45.8	43.4					
1844	41.6	39.6	38.8	40.0	38.2	41.9	46.5	42.2					
1845	40.0	38.2	38.3	38.8	39.3	41.6	48.8	43.2					
1846	39.3	37.0	39.1	38.5	43.9	44.1	53.9	47.3					
1847	40.7	36.8	40.8	39.4	46.8	45.3	56.7	49.6					
1848	42.4	37.0	41.1	40.2	46.2	45.1	55.3	48.9	42.0				42.0
1849	44.5	39.7	41.8	42.0	45.4	46.0	52.2	47.9	50.8				50.8
1850	46.9	44.7	43.9	45.2	44.6	45.1	48.2	46.0	58.0				58.0

Progressive Averages of Precipitation, 1834-1896.

Plate II.

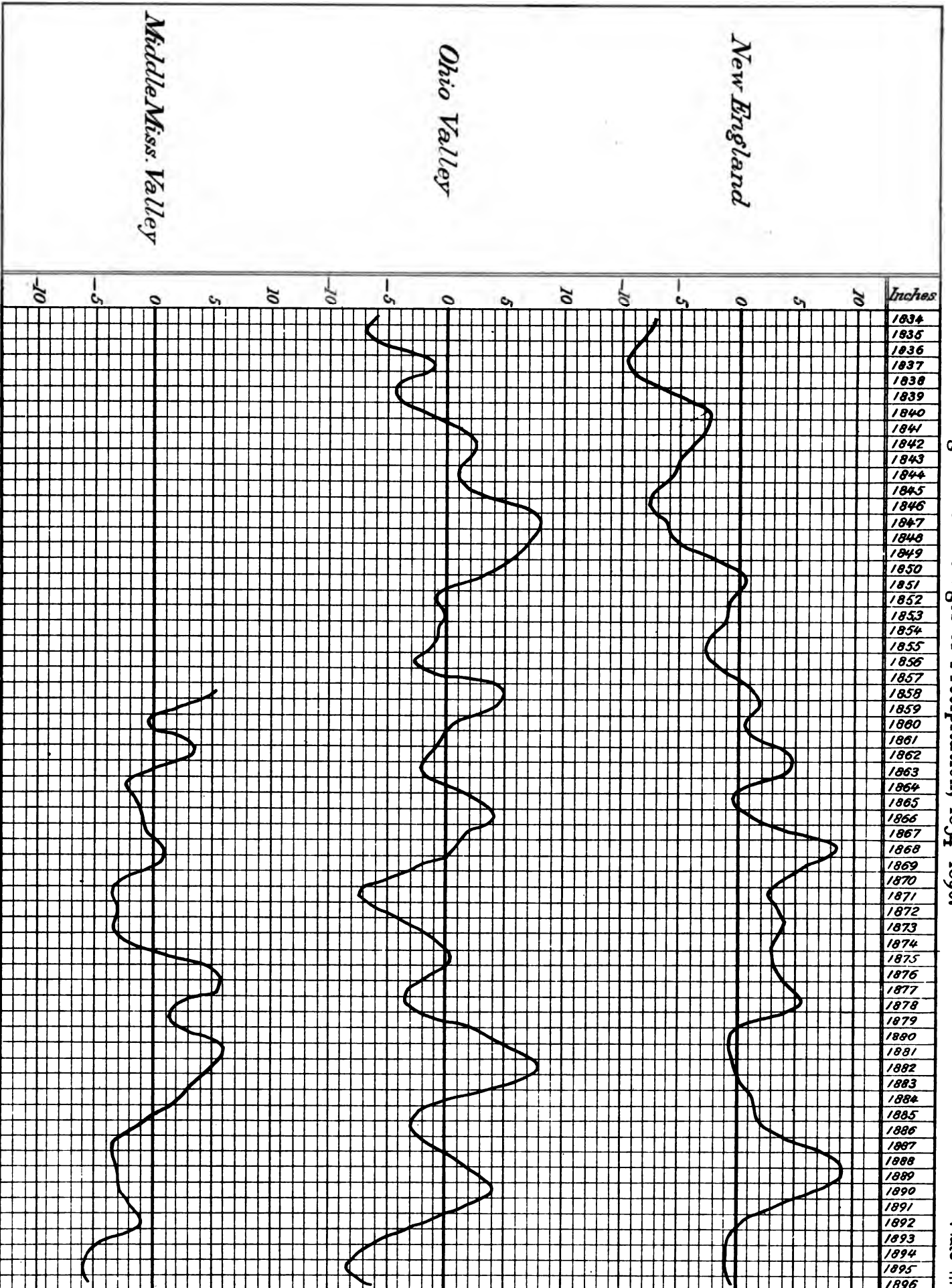


TABLE IV.—*Progressive averages of precipitation*—Continued.

Years.	Southeastern New England.				Upper Ohio Valley.				Middle Mississippi Valley.				
	Boston.	New Bedford.	Providence.	Mean.	Marietta.	Portsmouth.	Cincinnati.	Mean.	Muscatine.	Monticello.	Marengo.	Peoria.	Mean.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
1851	47.6	46.0	44.6	46.1	42.7	40.8	44.9	42.6	61.6	.....	.....	.....	61.6
1852	47.5	42.8	45.2	45.2	41.1	35.5	45.0	40.5	56.7	.....	.....	.....	56.7
1853	47.2	40.8	46.8	44.9	40.2	33.8	49.9	41.3	44.2	.....	.....	.....	44.2
1854	46.7	40.4	45.7	44.3	40.2	35.8	46.7	40.9	34.2	.....	.....	.....	34.2
1855	47.7	38.4	42.8	43.0	39.9	38.6	42.3	40.3	33.0	.....	.....	.....	33.0
1856	51.0	36.7	42.2	43.3	40.1	39.8	36.9	38.9	37.3	.....	.....	.....	37.3
1857	53.9	38.6	43.7	45.4	44.8	42.8	37.7	41.8	42.4	38.5	.....	.....	40.4
1858	54.6	42.2	44.5	47.1	50.1	46.1	42.3	46.2	43.8	39.6	39.6	39.0	40.5
1859	54.0	48.7	43.5	47.1	49.2	44.5	42.8	45.5	39.3	37.6	35.9	37.0	37.4
1860	53.2	43.0	42.7	46.3	45.3	40.6	40.6	42.2	36.4	36.2	33.5	34.3	35.1
1861	54.7	42.6	45.0	47.4	43.4	39.4	39.7	40.8	40.0	39.4	35.0	35.9	37.6
1862	58.6	42.7	48.4	49.9	41.9	39.1	39.2	40.1	41.2	41.5	34.4	37.8	38.7
1863	59.1	42.5	48.0	49.9	40.7	38.8	38.2	39.2	36.3	37.8	30.5	36.1	35.2
1864	54.4	42.0	44.8	47.1	42.4	41.5	39.0	41.0	32.8	34.1	29.7	34.2	32.7
1865	50.7	41.8	43.8	45.4	45.6	45.6	41.7	44.3	32.8	35.1	33.2	34.1	33.8
1866	52.0	42.9	45.8	46.9	47.0	46.7	42.2	45.3	33.4	36.0	35.5	33.0	34.5
1867	56.7	46.2	48.3	50.4	45.9	45.4	40.3	42.9	35.3	34.5	36.6	32.0	34.6
1868	60.5	49.3	49.9	53.2	43.7	44.0	39.4	42.4	37.8	34.0	38.8	33.8	36.1
1869	58.6	49.4	49.8	52.6	40.9	42.0	37.6	40.2	37.0	34.8	38.0	34.2	35.9
1870	52.6	48.2	48.9	49.9	37.5	38.3	34.0	36.6	33.9	33.0	33.5	32.1	33.1
1871	49.2	47.6	48.7	48.6	34.3	35.1	32.8	34.1	33.1	31.8	30.5	32.6	32.0
1872	49.9	48.2	49.2	49.1	34.9	35.9	35.2	35.3	33.2	31.7	29.9	35.3	32.5
1873	50.0	49.5	49.0	49.5	38.1	39.5	38.1	38.6	32.8	31.5	28.9	35.0	32.0
1874	48.6	50.1	48.7	49.1	39.9	41.9	40.5	40.8	35.1	32.0	29.5	34.0	32.6
1875	48.5	48.1	49.4	48.7	40.0	42.1	43.3	41.8	40.7	36.5	33.0	36.6	36.7
1876	50.5	45.8	50.6	49.0	39.1	39.9	44.0	41.0	45.0	42.9	35.6	39.4	40.7
1877	53.9	45.8	52.0	50.6	37.2	36.0	42.4	38.5	44.1	44.3	35.1	37.9	40.4
1878	54.3	46.9	52.5	50.9	35.9	34.5	43.8	38.1	39.8	41.7	33.5	34.3	37.3
1879	49.4	43.7	51.1	48.1	37.0	37.7	48.4	41.0	37.9	41.8	33.8	33.9	36.6
1880	45.4	41.4	50.2	45.6	40.4	42.7	51.1	44.7	38.6	44.4	36.7	37.0	39.2
1881	45.1	40.9	50.7	45.6	45.2	46.8	51.0	47.7	42.4	44.0	39.2	39.5	41.3
1882	43.9	42.3	50.7	45.6	48.4	49.1	50.4	49.3	44.3	40.0	38.4	39.6	40.6
1883	43.6	45.1	50.5	46.1	46.5	47.7	47.6	47.3	43.8	37.4	36.3	38.8	39.1
1884	43.9	48.4	50.4	47.6	41.8	43.6	41.5	42.3	43.0	37.3	35.2	37.2	37.9
1885	46.1	46.4	49.8	47.4	39.6	41.3	35.9	35.9	36.2	36.2	34.3	33.7	35.6
1886	46.8	48.1	50.7	48.6	40.1	41.7	33.6	38.5	33.8	34.0	35.2	30.6	33.4
1887	49.2	51.3	54.2	51.6	42.6	42.9	33.8	39.8	32.6	32.8	30.6	31.0	31.5
1888	52.9	58.6	66.9	54.5	46.4	44.2	34.5	41.7	33.9	32.6	28.6	33.2	32.1
1889	53.9	55.0	55.7	54.9	49.3	46.4	36.8	44.2	34.0	33.4	28.9	32.7	32.2
1890	51.3	54.2	52.1	52.5	49.0	47.1	39.4	45.2	33.3	34.6	31.9	31.0	32.7
1891	48.1	50.4	48.3	48.9	44.4	46.3	39.0	43.2	34.4	34.3	35.0	31.7	33.8
1892	45.5	47.2	45.8	46.2	39.1	42.5	37.2	39.6	35.3	32.5	36.0	33.0	34.2
1893	43.6	46.6	46.6	45.3	35.7	38.8	35.4	36.6	33.2	29.4	34.5	32.7	32.4
1894	42.8	45.8	46.6	45.1	33.1	36.1	32.5	33.9	29.9	25.7	32.0	32.5	30.0
1895	42.7	44.6	47.0	44.8	33.1	35.5	30.9	33.2	28.3	24.6	30.5	33.6	29.2
1896	43.7	45.3	47.9	45.6	36.2	36.7	31.9	34.9	28.2	26.3	30.4	35.0	30.0
Mean	.....	.....	.....	45.8	.....	.....	.....	41.3	.....	.....	.....	.....	35.2

As before stated, the fact that a period of abundant rain was followed by one of diminished fall, culminating in the extensive droughts of 1894-95, led to an examination of the older rainfall registers of the United States. The examination has not been productive of positive results, so far as the rainfall periodicity of the whole country prior to 1877 is concerned. This result might have been inferred on the ground that the conditions which determine the character of fall in the several rainfall districts are varied and complex, wherefore failure of rains in all districts on the one hand, or a preponderance of rain on the other, is not likely. In tropical India the variation of rainfall in different years is intimately connected with the strength and persistence of the summer monsoon, and the problem is much simplified. The rainfall of higher latitudes, however, partakes largely of the nature of fortuitous phenomena whose underlying causes are difficult of ascertainment.

The data given in the table and graphically expressed on Plate II are not wholly barren of results. It may, therefore, be instructive to examine them more closely, since it is only by studying the details of the rainfall régime of smaller geographical divisions that we may expect to gain a better knowledge of the vicissitudes of rainfall of greater divisions.

Plate II exhibits the fluctuation in the yearly amounts of precipitation during the years given at the top of the sheet. The heavy horizontal lines represent the normal precipitation. The amount that the actual fall of any year exceeded or fell short of the normal may be found by noting the intersection of the curved lines with the smaller horizontal lines, whose values are given in inches on the left margin.

If periods of heavy and light rainfall alternated regularly, the line of departure from the normal (the curved line) would rise and fall in a series of bends or inflections precisely as the temperature rises and falls with the alternation of day and night. Reference to the diagram itself will best show how closely the fall of the three regions under consideration approaches any sort of periodicity. The Ohio Valley curve is more symmetrical than the others, and there appears to be a rough periodicity of about nine years. Thus there were periods of heavy rainfall about 1837, 1847, 1858, 1866, 1875, 1882, and 1890, and of drought in 1839, 1856, 1863, 1871, 1878, 1886, and 1895. Should this periodicity hold, the crest of the next period of heavy precipitation will fall about 1899.

The curve for the middle Mississippi Valley gives little indication of any sort of periodicity. The important facts shown are: (1) The deficiency of the last ten years was preceded by a corresponding excess, and (2) there were no marked fluctuations between 1858 and 1875. Prior to 1858, if the record made at Muscatine can be relied upon, the rains were heavier than have since been reported. There is also an indication of a period of heavy rainfall at St. Louis, Mo., in the fifties, but the years of maximum fall do not coincide with those at Muscatine.

Comparing the curves one with another, it is readily seen that they are not symmetrical, especially as regards the epochs of maximum and minimum fall. Thus the period of relatively light rainfall in New England during 1880-1883 was one of heavy rainfall both in the Ohio and middle Mississippi valleys. Likewise 1878 was a year of heavy rainfall in New England, but of drought in the Ohio Valley.

The New England curve shows a rather remarkable increase in precipitation, beginning about 1845 and reaching a climax in 1888-89, if the droughty period of 1880-1882 be excepted. This fact is so contrary to general belief that as an additional check upon the accuracy of the figures the simple arithmetical means of the annual amounts of each station have been computed in periods of ten years each, beginning in 1837. There was no especial reason for beginning with that year, except that it brought the last ten-year period to a close with 1896. The ten-year means are given below.

Periods.	Boston.	New Bedford.	Providence.
	<i>Inches.</i>	<i>Inches.</i>	<i>Inches.</i>
1837-1846.....	41.3	38.8	38.4
1847-1856.....	46.5	40.4	43.9
1857-1866.....	54.5	42.1	45.1
1867-1876.....	52.6	48.4	49.4
1877-1886.....	46.8	44.6	50.8
1887-1896.....	47.1	49.6	50.1

Thus it appears that there was a period of about forty years (1837-1876) during which there was a total increase in the annual precipitation at the stations named of about 10 inches (from an average of 41 inches to an average of 52 inches at Boston, etc.). But further examination shows that the increase was largely a local phenomenon, since it is not apparent at points west of the Connecticut River. The register of Amherst, in west-central Massachusetts, shows an increase from 1837 to 1846, and but little variation in later decades. The figures are as follows:

Average precipitation, Amherst, Mass.

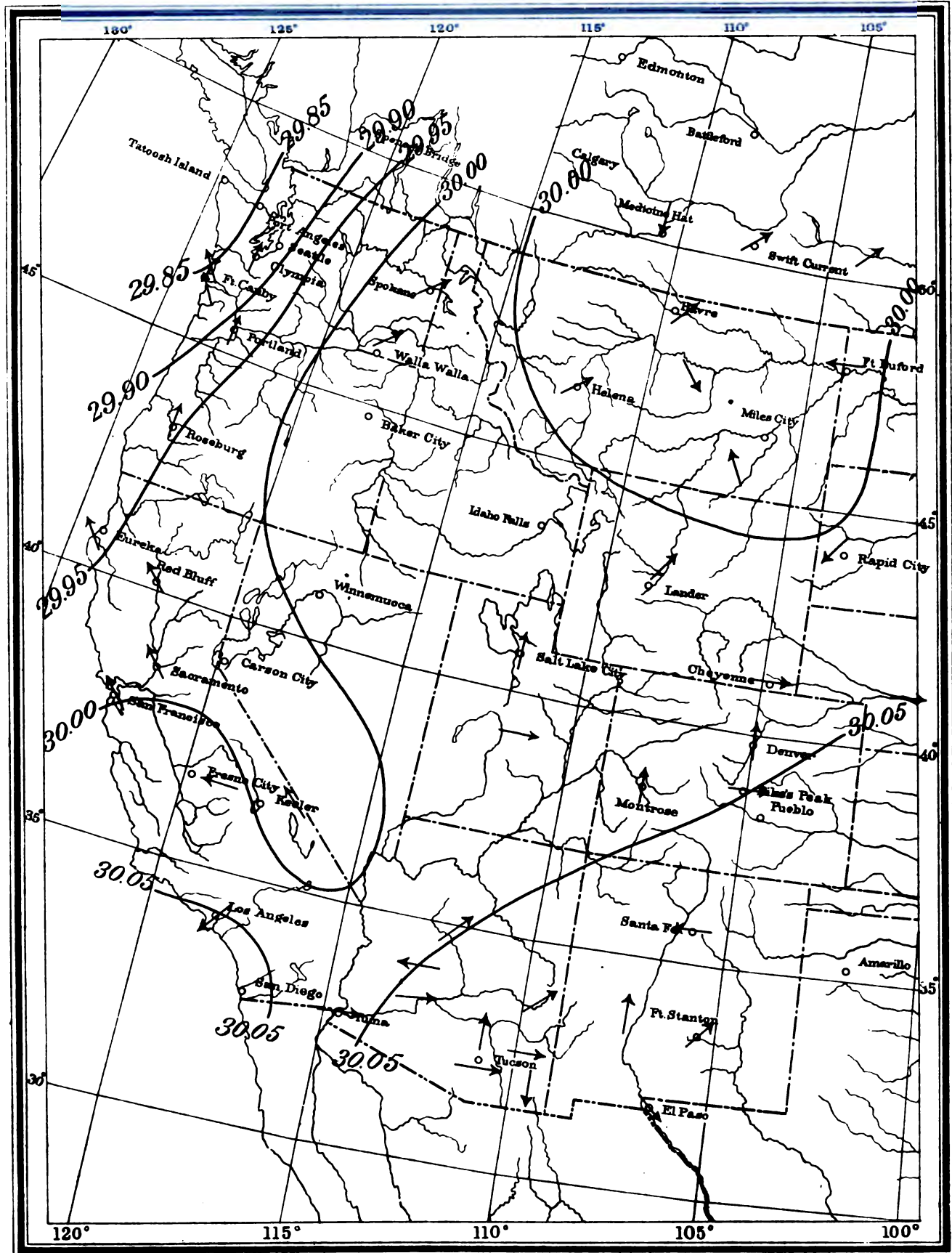
	<i>Inches.</i>
1837-1846.....	41.5
1847-1856.....	45.6
1857-1866.....	45.5
1867-1876.....	45.6
1877-1886.....	42.2
1887-1896.....	45.4

Some interesting and possibly suggestive facts may be obtained by an inspection of the years of least rainfall shown by full-faced type (Table IV). There is a suggestion in these data that, while the more intense droughts are of comparatively small area, yet what might be termed the dominating influence is often felt over a very large extent of territory. The drought of 1860, which was most severe in Kansas and Missouri, was also felt in the middle Mississippi Valley and again in New England, although in the latter region, more as a slight obstacle in the path of a

Pressure Distribution and Prevailing Winds, December, 1889.

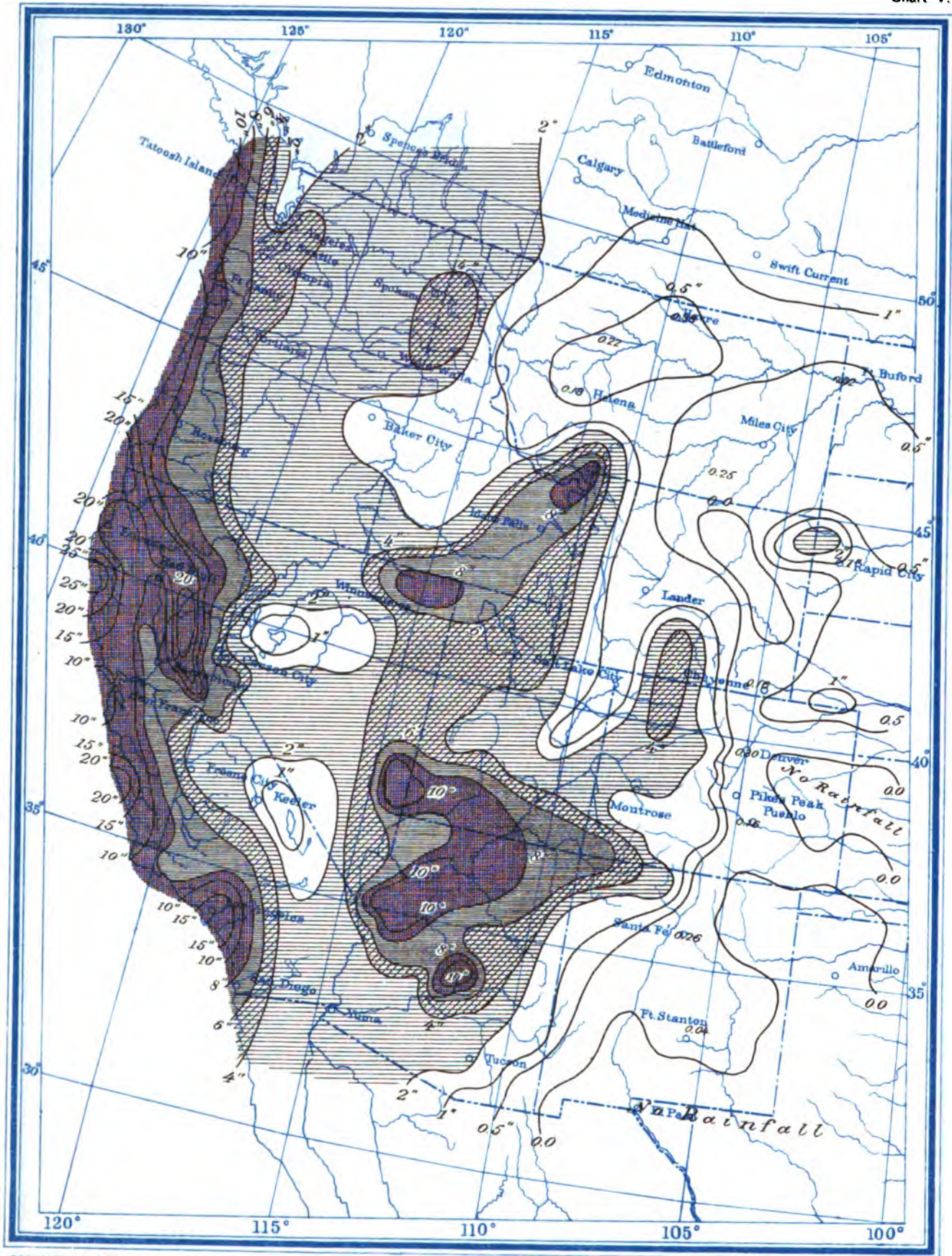
(Typical of a wet month on the California Coast.)

Chart IV.



Rainfall, December, 1889.

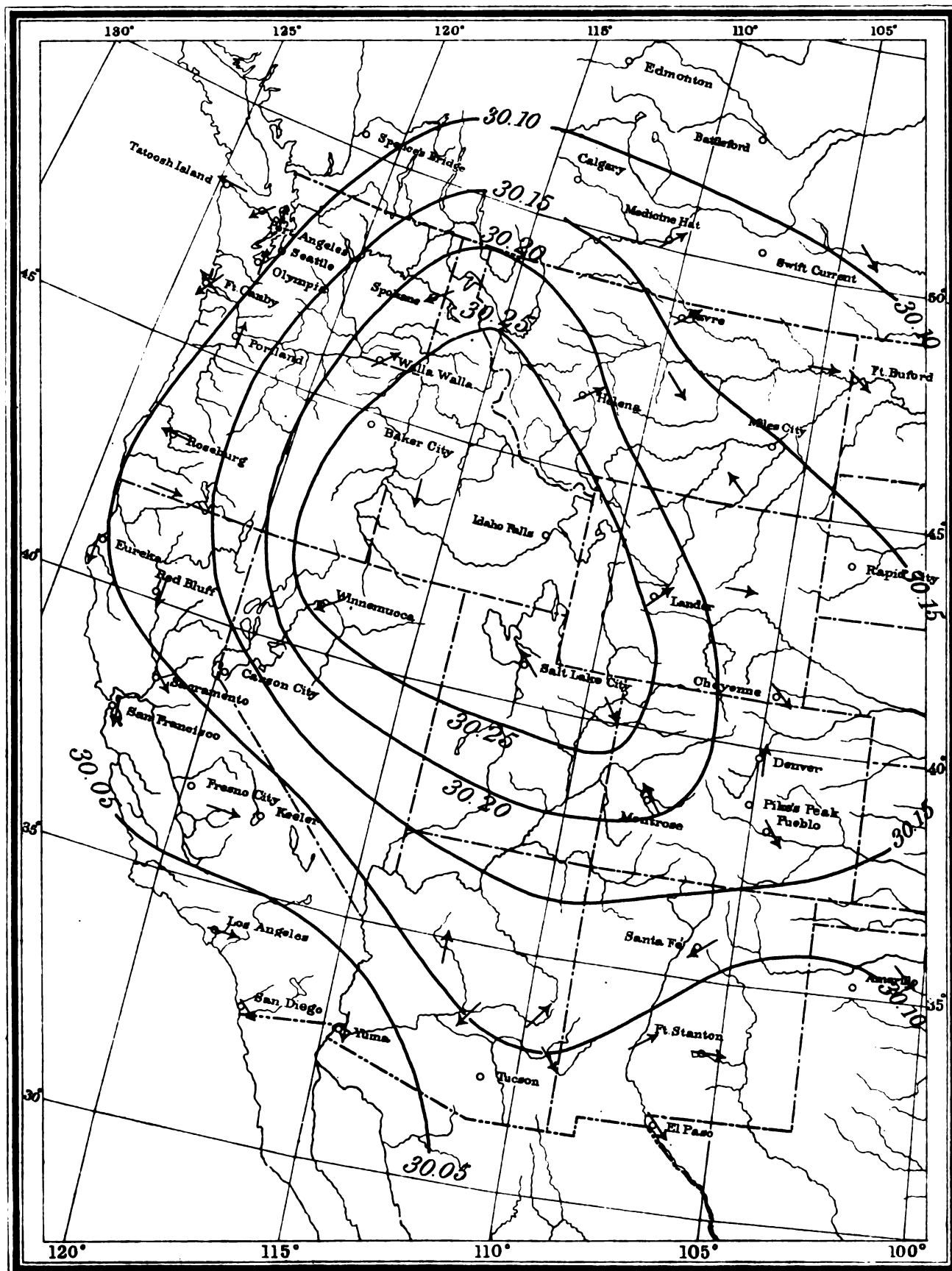
Chart V.



Pressure Distribution and Prevailing Winds, January, 1889.

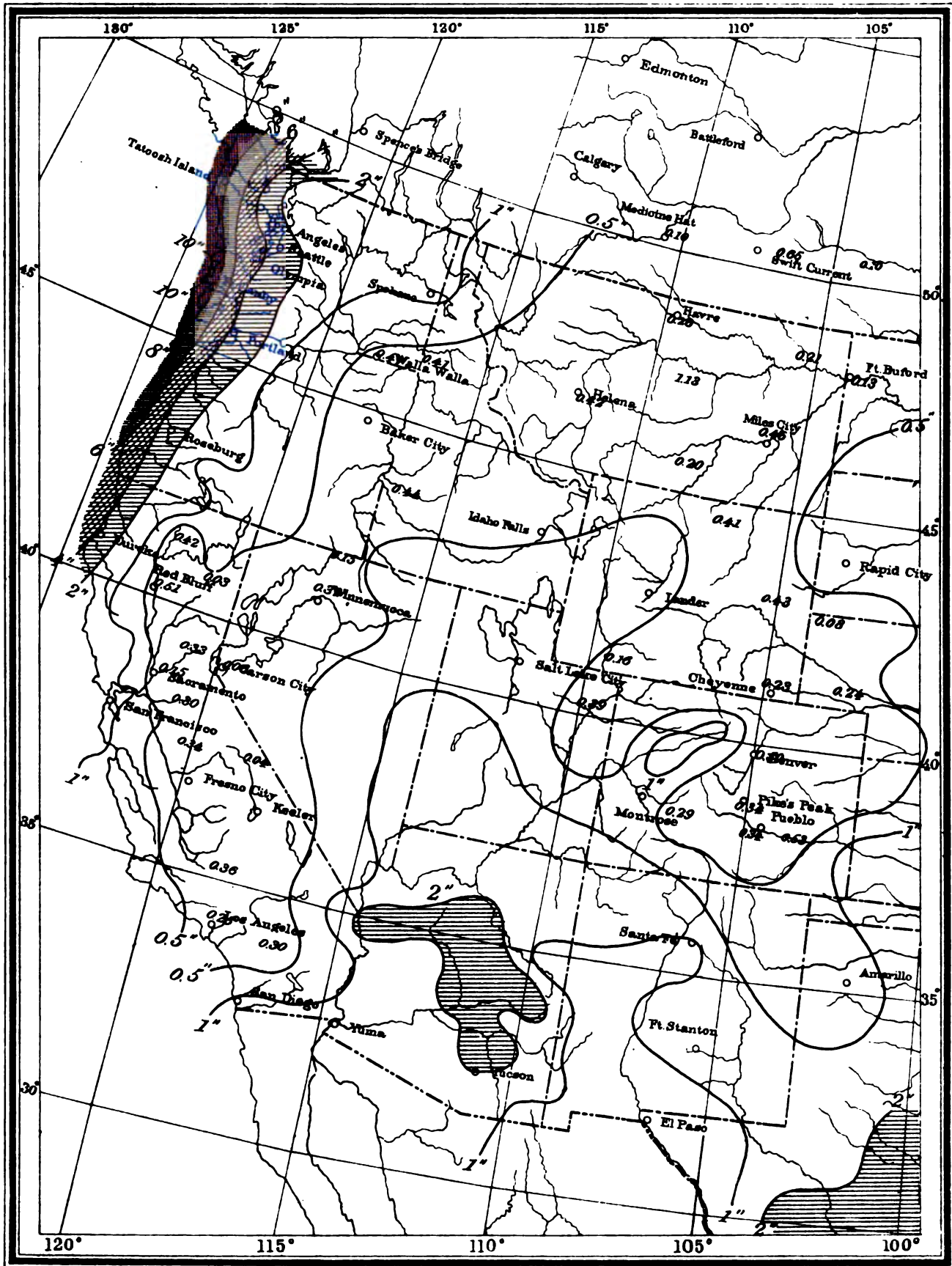
(Typical of a dry month on the California Coast.)

Chart VI.



Rainfall, January, 1889.

Chart VII.



wave of increasing precipitation than as a period of absolute drought. So also the severe drought of 1835 in the Ohio Valley was felt in New England as a moderate drought only.

The drought of 1863 in the upper Ohio Valley and Lake Region appeared in the middle Mississippi Valley in the following year, and in the year next following (1865) there was a period of relative drought in New England. From these, and other facts, it may be assumed that there is not a progressive movement from west to east in droughts as in ordinary weather conditions. There is, however, a tendency for them to recur in irregular periods of from four to eleven years.

Finally, it may be observed that the drought of 1894-95, whether measured by the amount of rain that fell or the time that it persisted, was the most severe that has ever been experienced in the Ohio and Mississippi valleys.

One other phase of rainfall variability that may be touched upon is the tendency in nature of one extreme to be followed by another, and this oscillation from dry to wet, or vice versa, may be accomplished quickly or it may run through three or four years. One of the most remarkable individual cases of a complete reversal within two years is that of Mount Hamilton, California, on whose summit 90.1 inches of rain and melted snow were measured in 1884, but only 18.4 inches in 1885. The year 1884 was one of generally heavy precipitation throughout the Pacific Coast and, in a greater or less degree, over the Plateau region west of the Rocky Mountains during the months of January, February, March, and December. In a great many cases the early part of 1885 was dry. Another interesting case is that of the general drought over a large portion of the Plateau region in 1839. The Humboldt River in Nevada, which had flowed uninterruptedly for thirty years, went dry. The precipitation on the headwaters of that stream had been decreasing gradually for several years, reaching a minimum of 5.3 inches in 1887, and continuing low during 1888 and 1889. Elsewhere the drought was also severe, but it was finally broken by a succession of atmospheric disturbances, which passed over the Plateau region far south of the usual course of such storms and precipitated heavy rains over central and lower California, Nevada, Arizona, and Utah. As much rain fell at Fort Mohave, in the desert of that name, in the single month of December as fell in the four years 1880-1883. On the other hand, the precipitation of Washington and Oregon was exceedingly scanty, being the least ever known in December at a number of places. The whole system of atmospheric circulation and storm movement seems to have been shifted for the time being 5° or 10° to the southward. The meteorological conditions for the month were so exceptional, and withal so instructive, that they have been reproduced as Charts IV and V, respectively. The first named shows the pressure distribution and prevailing winds for the month; the second, the precipitation. To complete the series, two additional charts, Nos. VI and VII, have been reproduced, as illustrating the conditions that obtain during a month of deficient rainfall on the Pacific Coast.

The rainfall of the Pacific Coast is due, first, to its position in latitude, viz, on the southern edge of the great highway of storms striking the continent from the North Pacific, and, second, because the ordinary ascensional movement of air in cyclonic storms is greatly augmented by the sharp contrasts of valley and mountain, which tend to force upward relatively large masses of warm, moist air.

The prevailing winds and the pressure distribution shown on Chart IV are very favorable to heavy precipitation in California and the Plateau region. The pressure distribution is abnormal, as, also, the rainfall; indeed, a similar configuration of the isobars could not be found in a brief search through the records of the last twenty years. The chart represents an extreme condition, viz, a transfer of the usual track of low-pressure areas of the northern boundary southward to central California and the plateau regions of Nevada and Arizona, thus giving copious rains to a region the greater portion of which is ordinarily almost destitute of rain. Such a condition may not happen again in the next twenty years, but, having once occurred, it must henceforth be included among the possibilities of Pacific Coast weather.

Ordinarily the plateau region of Nevada and Utah in winter is covered by an area of high pressure whose characteristics are comparatively clear skies and little or no precipitation. Chart VI shows the winter high of the great basin as having a westward and northwestward extension, so that Washington, Oregon, and California come under its influence and northerly winds and clear weather prevail in California, a condition, it is needless to say, inimical to the precipitation of moisture.

The average paths of atmospheric disturbances in the United States have been determined by Prof. F. H. Bigelow (Weather Bureau Bulletin No. 20, Storms, Storm Tracks, and Weather Forecasting), but the causes which lead to the migrations of storms from beaten paths, and upon which the character of the rainfall, whether scant or excessive, seems to depend, are not known.

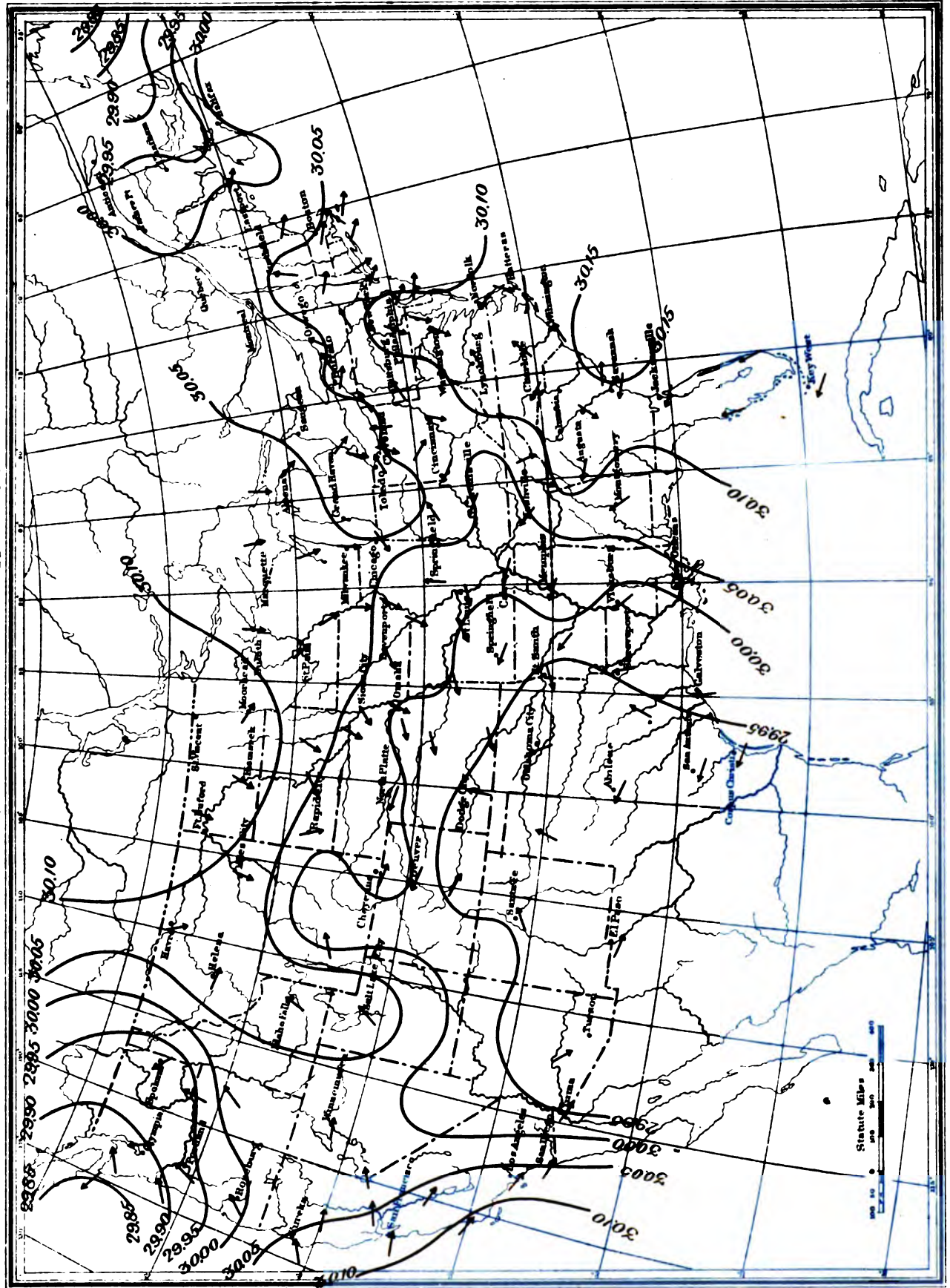
It will doubtless be remembered that the drought of 1895 east of the Rocky Mountains was broken in many States during the early part of 1896, although at the end of that year a deficiency of rainfall still existed in the South Atlantic and Gulf States. The present spring (1897) has witnessed a flood in the Lower Mississippi greater than any for a number of years previous. The distribution of pressure and the prevailing winds favorable to heavy rains in the central and lower valleys (March, 1897) are shown on Chart VIII; those unfavorable (March, 1885), by Chart X. Charts IX and XI show the distribution and lineal depth of rainfall for corresponding periods, and the tracks of low-pressure areas have also been added in red.

We can do no more than present the facts as they exist. The treatment of this subject has, necessarily, been superficial, and, in a measure, unsatisfactory. It has not been possible, nor is it believed to be desirable to undertake, with the data available at present, a systematic investigation of the underlying causes of rainfall variation, but rather to carry along such an investigation in connection with other studies of the general atmospheric circulation.

Pressure Distribution and Prevailing Winds, March, 1897.

(A wet March in the Mississippi Valley.)

Chart VIII.



Precipitation, March, 1897.

(Tracks of low pressure areas in red.)

Chart IX.

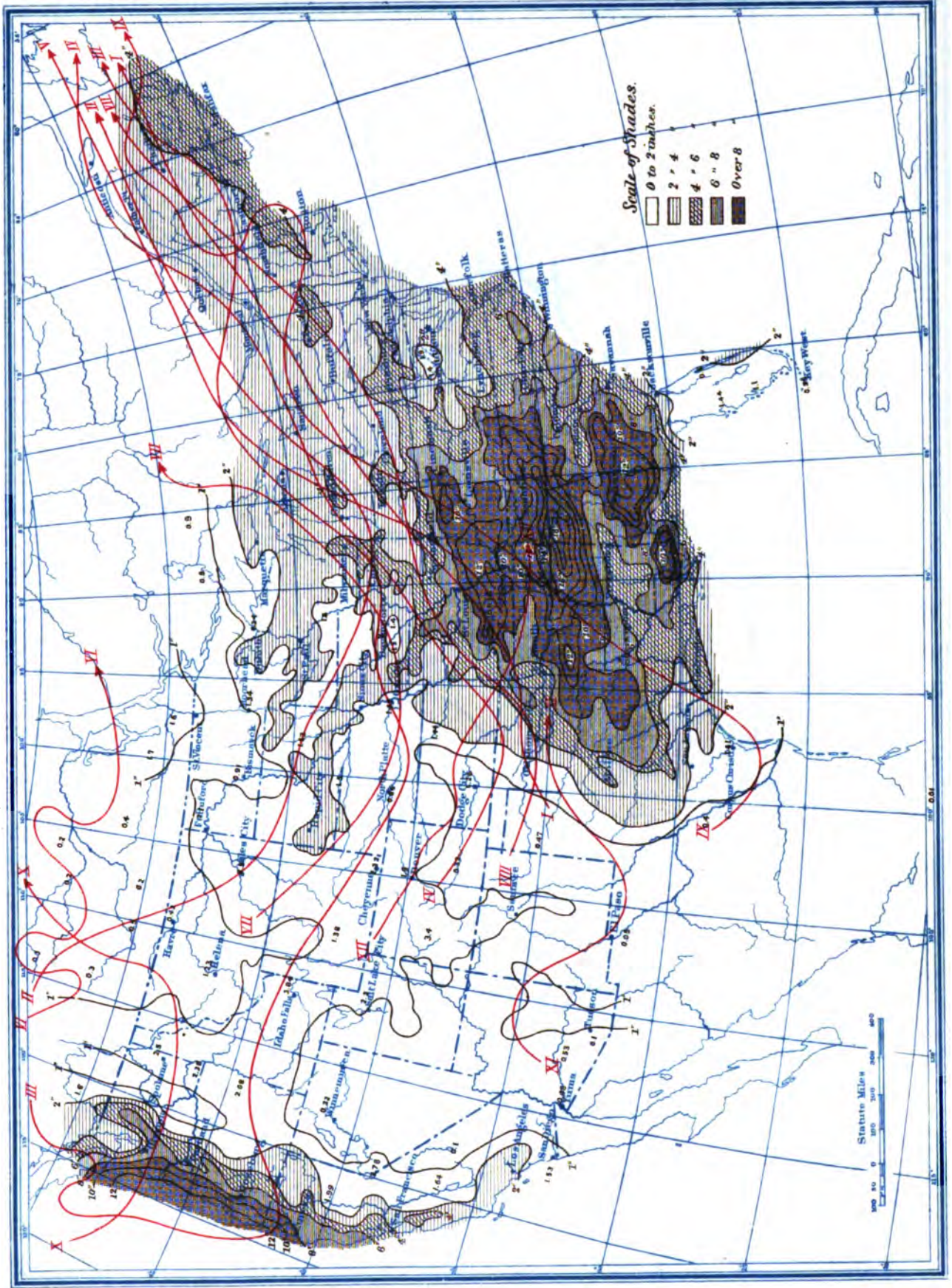




Chart X.

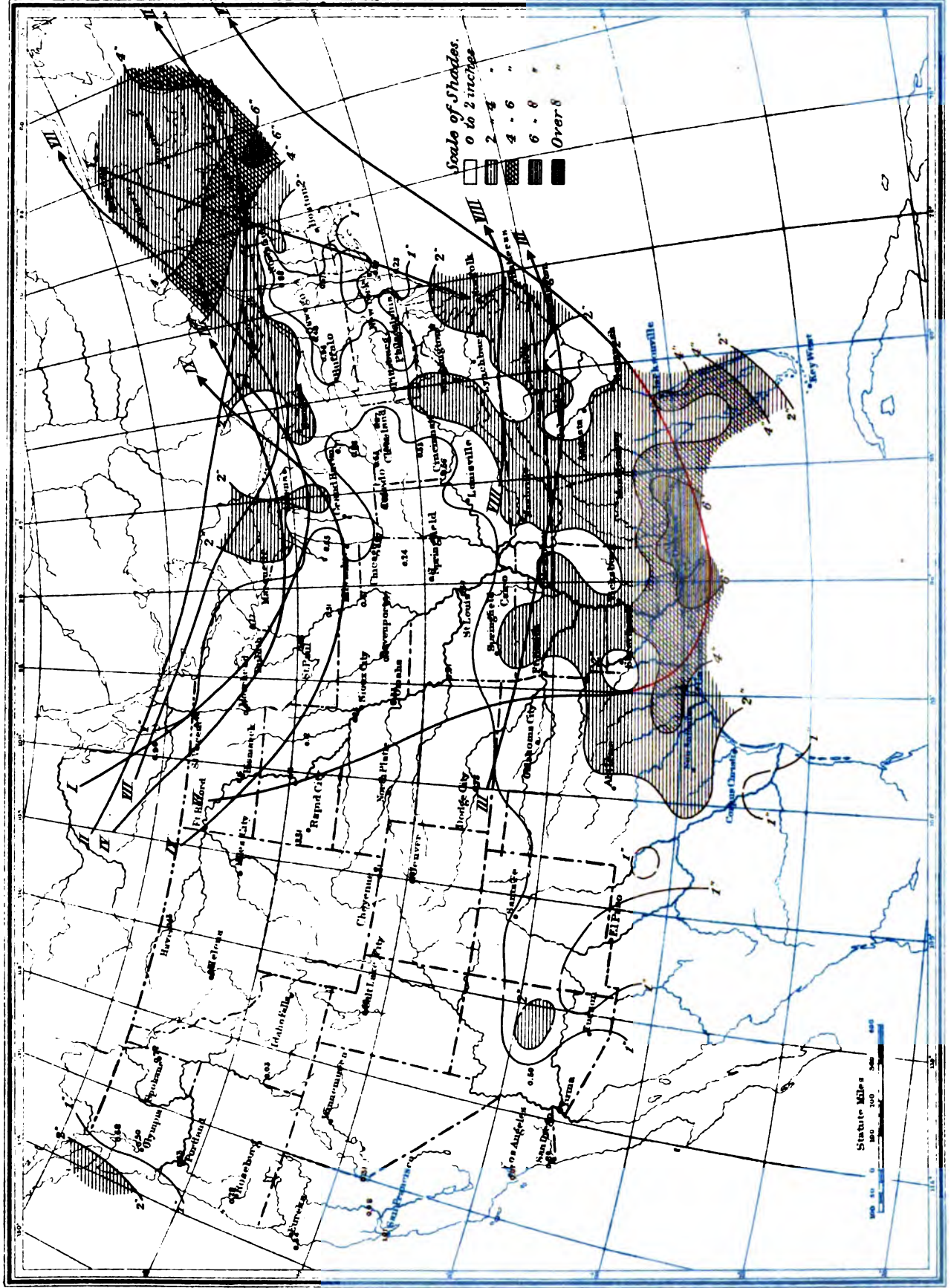
●



Precipitation, March, 1885.

(Tracks of low pressure areas in red.)

Chart XI.



VI.—DETAILS OF PRECIPITATION BY GEOGRAPHIC DISTRICTS.

There will be found in this chapter tables of mean monthly and annual precipitation, greatest and least annual precipitation ever recorded, the geographic coordinates of the stations, and other details. The tabular matter has been supplemented by a brief text, in which a short account of the general topographic features of each district and other information is given.

In selecting the stations which appear in the tables, due regard was had for length and continuity of record and accuracy, the endeavor being to present the latest and most reliable information respecting the rainfall of the United States, so arranged that it can be used either as a whole or merely for a single geographic district.

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TABLE V.—Monthly and annual averages, of precipitation, annual extremes, etc.

Stations.	Latitude.	Longitude.	Elevation.	Record.		Whole years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.			Ratio.	
				From—	To—														Mean.	Ex- tremes.			
																				Highest.	Lowest.		
WASHINGTON.																							
	°	'	°	'	Feet.		In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.		
Neah Bay	48 22	124 37		40	1863 1896	15	16.4	12.3	11.7	7.6	5.2	5.0	2.2	2.5	6.9	9.5	14.3	10.4	109.7	136.0	79.6	124 73	
Olympia	47 03	122 53		36	1877 1896	18	8.1	6.7	5.0	4.0	2.7	1.9	0.7	0.7	2.8	4.7	7.7	9.8	54.5	73.4	33.6	135 62	
Ellensburg	47 00	117 32		1,500	1884 1896	7	1.6	0.7	0.5	0.9	0.9	0.3	0.3	T	0.5	0.4	1.4	1.5	9.0	11.8	6.7	181 74	
Colville, Fort	48 43	117 50		1,963	1859 1880	13	2.4	1.6	1.6	1.0	1.8	1.5	1.3	0.6	0.6	1.1	1.9	1.8	18.8	32.7	8.4	174 45	
Spokane	47 40	117 25		1,909	1881 1896	15	2.5	1.9	1.4	1.4	1.5	1.6	0.7	0.4	1.0	1.6	1.9	2.7	18.6	25.7	13.5	138 73	
Walla Walla	46 02	118 30		930	1857 1896	27	1.6	1.4	1.5	1.4	1.7	1.2	0.5	0.3	0.8	1.4	1.7	1.9	15.4	23.1	7.1	150 46	
OREGON.																							
Astoria	46 11	123 48		38	1850 1896	34	12.8	8.5	9.2	5.7	3.8	3.1	1.2	1.4	3.4	5.6	10.5	12.3	77.0	100.5	49.4	131 64	
Portland	45 32	122 43		80	1870 1896	27	7.0	5.9	5.5	3.4	2.5	1.8	0.5	0.6	1.6	3.7	6.1	7.6	46.2	67.2	30.8	145 67	
Cascade Locks	45 40	121 50		150	1879 1896	16	12.9	9.9	7.2	6.5	3.7	2.6	0.9	0.6	3.7	7.2	9.7	14.4	79.3	100.6	56.2	127 71	
The Dalles	45 33	121 12		106	1850 1896	28	3.7	2.3	1.9	0.8	0.8	0.5	0.2	0.2	0.9	1.3	2.7	3.6	18.9	43.7	11.9	231 65	
Bandon	43 05	124 30		40	1878 1896	19	12.6	8.7	7.7	5.9	3.9	1.8	0.6	0.5	2.7	5.2	6.9	12.2	68.7	104.0	47.7	151 66	
Roseburg	43 13	123 20		523	1877 1896	19	6.3	4.8	3.6	2.7	2.1	1.2	0.4	0.3	1.1	2.7	4.0	6.4	35.6	46.9	22.4	132 63	
Klamath, Fort	42 41	121 50		4,200	1864 1889	13	3.3	2.5	2.5	1.6	1.2	0.8	0.4	0.3	0.5	1.6	3.3	3.5	21.5	30.6	9.6	142 44	
Harney, Camp	43 00	119 00		4,600	1867 1880	11	1.5	1.1	1.3	1.0	0.9	0.8	0.3	0.2	0.2	0.5	1.4	1.6	10.8	18.2	4.7	169 44	

WASHINGTON AND OREGON.

Physical features.—The western third of both States is traversed by two parallel mountain ranges, with a fertile and thickly populated valley between them. The Coast Range does not reach an altitude in general much greater than 2,000 feet in Oregon and 3,000 in northwestern Washington. The Cascade Range is much the loftier of the two, both as regards isolated peaks and the general surface, the latter being 6,000 feet or more in altitude for almost the entire length of Oregon, and probably half as great a distance in Washington. The Blue Mountains in north-eastern Oregon also reach an altitude of 5,000 feet and over. The country east of the Cascades in Oregon is a lofty plateau, whose general surface, excluding the valleys of streams tributary to the Columbia and Snake rivers, is from 4,000 to 6,000 feet above sea level.

The Cascade Range divides the State of Washington into two parts, eastern and western Washington, wholly unlike, both as to climate and topography. Eastern Washington abounds in rolling plains and valleys. Western Washington contains the most important waterway of the State, Puget Sound, which, with its bays and inlets, embraces an area of nearly 2,000 square miles. The west coast of the State is a mountainous region, heavily timbered, and almost without settlement from Cape Flattery to Grays Harbor.

Rainfall of Washington.—The average annual rainfall of Washington varies from about 110 inches on the shore line of Clallam County to less than 10 inches in the Yakima Valley on the eastern or leeward side of the Cascades.

The area of heavy rainfall is coextensive with the western coast region in latitude, and doubtless extends eastward to the summit of the Olympic and Cascade ranges. Measurements at Aberdeen, about midway of the western coast and 18 miles inland, indicate an average fall of about 80 inches per annum. Farther south, at Astoria, Oreg., separated from Washington by the Columbia River only, the average fall is 77 inches.

The rainfall of Puget Sound Basin varies from 54 inches at Olympia to 22 inches at Fort Townsend, at the northern extremity. The rainfall on the southern shore line of the Straits of Fuca is also quite variable, diminishing from 110 inches at Neah Bay to 29 inches at Port Angeles and to 22 inches at Fort Townsend, at the mouth of Puget Sound, as above mentioned. The physical causes that contribute to the rapid decrease are not clearly apprehended.

Both Port Angeles and Neah Bay are situated on the south shore of the Straits of Fuca, less than 60 miles apart. The Olympic range of mountains, with elevations varying from 2,000 to 4,000 feet, parallels the shore line at a distance of from 6 to 8 miles. South of Neah Bay—that is, inland toward the mountains—the country is hilly and heavily timbered, with a range of hills from 200 to 1,000 feet above sea level, running in a general easterly and westerly direction and about 4 miles back from the straits. The surface winds at Neah Bay during rains are from a direction between south and east, or generally from a land area. At Port Angeles the surface winds differ from those of Neah Bay only in having at times a westerly component; but, since westerly winds are dry winds on the Pacific Coast, the explanation of the phenomenon must be sought on other lines.

The rain winds of the Pacific Coast are generally from a direction between south and east, or from a land surface, contrary to a somewhat prevalent notion that they blow from the warmer ocean to the colder land area.

The rainfall on the western slope of the Cascade Range is greater than in the Puget Sound Basin, as might be expected, but on the eastern flank, less than 200 miles from the Pacific, the annual fall, at an elevation of about 1,000 feet, as in the Yakima Valley, dwindles to about 10 inches.

No rainfall observations have been made over a great part of the Great Plain of the Columbia, locally known as the Big Bend country. It is quite probable that the fall is between 10 and 15 inches per annum, and this statement is borne out by the fact that between the mouth of the Spokane and the junction of the Snake, a distance of 280 miles, no stream of any consequence flows northward or westward from the Great Plains into the Columbia. On the other hand, a number of streams fed by the precipitation on the Cascades flow into the river from the opposite side, thus affording an abundance of water for irrigation or other purposes.

The rainfall of the extreme eastern line of counties is about 18 inches per annum, decreasing gradually to the westward until the minimum of the State (10 inches) is reached in the Yakima Valley.

TABLE V.—Monthly and annual averages, of precipitation, annual extremes, etc.—Continued.

Stations.	Latitude.	Longitude.	Elevation.	Record.		Whole years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.			Ratio.	
				From—	To—														Mean.	Highest.	Ex- tremes. Lowest.		
CALIFORNIA.																							
Coast.																							
	° ' "	° ' "	Feet.				In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.		
Crescent City	41 45	124 12	50	1885	1896	11	13.1	8.9	9.1	7.1	4.5	2.0	0.4	0.1	1.8	4.4	8.8	13.9	71.0	82.2	47.5	116	67
Fort Humboldt.....	40 46	124 10	50	1854	1896	28	6.6	5.2	5.4	3.5	1.7	0.7	0.1	0.1	0.8	2.1	3.8	7.1	37.1	60.4	21.9	163	59
Mendocino.....	39 18	123 48	.....	1871	1890	14	10.0	8.7	7.2	4.5	1.3	0.4	0.1	T.	0.6	2.8	6.5	9.3	51.5	75.3	26.0	146	50
Fort Ross.....	38 35	123 05	.....	1874	1896	20	12.0	6.8	7.3	4.2	1.8	0.7	0.1	T.	0.8	2.8	6.8	8.8	52.2	88.0	23.6	169	45
San Francisco.....	37 48	122 26	60	1849	1896	47	5.0	3.5	3.1	1.9	0.7	0.1	T.	T.	0.2	0.9	2.8	5.2	23.4	38.7	12.0	165	51
Santa Cruz.....	36 58	122 02	25	1873	1896	20	5.4	4.0	3.6	2.4	1.0	0.2	T.	T.	0.5	1.7	3.1	5.3	27.2	44.9	16.8	165	52
Monterey.....	36 37	121 52	40	1847	1896	21	2.9	2.5	2.8	1.5	0.6	0.1	T.	T.	0.1	0.6	1.5	3.5	16.1	28.6	8.3	178	52
San Luis Obispo.....	35 18	120 39	270	1869	1896	24	4.8	3.6	3.2	1.8	0.8	0.1	T.	T.	0.2	1.1	1.9	4.4	21.4	50.0	12.2	234	57
Santa Barbara.....	34 25	119 40	20	1867	1896	29	3.8	3.4	2.3	1.3	0.4	0.1	T.	T.	0.1	0.7	1.7	3.9	17.7	38.8	8.1	219	46
San Diego.....	32 42	117 14	150	1850	1896	47	1.7	1.9	1.4	0.7	0.3	0.1	0.1	0.1	0.1	0.3	1.0	2.0	9.7	27.5	2.9	284	30
Northern interior.																							
Fort Gaston.....	41 05	123 15	397	1861	1892	28	10.4	8.0	7.4	4.7	1.9	0.8	0.2	0.1	0.8	2.8	7.0	10.5	54.6	71.2	34.9	180	64
Scott Valley.....	41 45	123 02	2,570	1859	1891	32	4.9	3.2	2.6	1.8	1.2	0.6	0.5	0.2	0.5	1.2	2.9	5.2	24.7	37.0	14.6	150	59
Yreka.....	41 45	122 32	2,635	1871	1896	22	3.5	2.1	1.5	1.1	1.3	0.6	0.5	0.2	0.4	1.1	2.2	3.0	17.5	28.0	9.4	160	54
Great Valley.																							
Redding.....	40 36	122 27	565	1874	1896	22	7.7	4.3	4.8	3.2	2.2	0.5	0.1	0.1	0.6	2.2	3.6	7.1	36.6	62.3	18.4	170	50
Red Bluff.....	40 10	122 15	342	1872	1896	25	4.5	3.5	2.9	2.0	1.2	0.4	0.1	T.	0.6	1.4	3.0	4.8	24.4	49.1	12.7	201	52
Marysville.....	39 09	121 35	69	1871	1896	24	3.4	2.7	2.3	1.6	0.9	0.3	T.	T.	0.3	1.0	2.0	3.7	18.2	33.8	11.2	186	62
Sacramento.....	38 35	121 30	64	1849	1896	47	3.9	2.8	2.9	1.9	0.8	0.1	T.	T.	0.2	0.7	2.1	4.5	19.9	34.8	8.4	175	42
Stockton.....	37 58	121 15	20	1853	1896	31	2.6	1.9	1.8	1.3	0.6	0.1	T.	T.	0.2	0.5	1.3	2.9	18.2	22.6	8.0	171	23
Fresno.....	36 44	119 48	295	1877	1896	19	1.5	1.3	1.4	1.2	0.4	0.1	T.	T.	0.2	0.4	1.0	1.8	9.3	18.0	5.7	194	61
Tulare.....	36 13	119 19	289	1874	1896	22	1.4	1.1	1.1	0.8	0.4	0.1	T.	T.	0.1	0.3	0.5	1.2	7.0	13.7	4.2	196	60
Foothills region.																							
Folsom City.....	38 40	121 10	182	1861	1896	25	4.7	3.4	3.5	2.3	1.2	0.2	T.	T.	0.4	1.1	2.7	4.6	24.1	34.7	8.5	144	35
Shingle Springs.....	38 39	120 55	1,393	1849	1894	25	7.2	4.5	5.4	3.0	1.5	0.2	0.2	0.0	0.3	1.2	4.0	7.6	35.1	67.7	18.4	193	52
Placerville.....	38 44	120 48	2,109	1874	1896	19	9.0	5.5	7.0	5.3	2.5	0.6	T.	T.	0.7	2.3	5.2	8.8	48.9	74.1	32.3	158	69
Grass Valley.....	39 15	121 02	2,448	1872	1896	24	10.1	7.2	7.5	5.2	2.5	0.6	T.	T.	0.8	2.5	5.4	9.1	50.9	79.1	27.3	155	54
Nevada City.....	39 17	120 00	2,500	1863	1896	26	11.6	7.5	8.3	5.4	2.4	0.6	T.	T.	0.7	2.2	6.9	11.8	57.4	102.8	30.0	179	52
Upper Sierras.																							
Bowman Dam.....	39 27	120 34	5,400	1871	1887	16	13.6	11.7	10.2	7.7	2.5	0.8	0.2	T.	0.6	3.3	7.2	13.8	69.8	119.5	43.5	171	62
Truckee.....	39 19	120 01	5,819	1870	1896	26	5.9	5.1	3.7	2.5	1.3	0.4	0.2	T.	0.3	0.9	2.4	4.6	27.3	43.7	8.9	160	33
Boca.....	39 24	120 06	5,531	1870	1896	25	4.3	3.7	2.6	1.5	0.8	0.1	0.1	T.	0.1	0.5	1.3	3.8	18.8	38.4	2.4	204	13
Los Angeles and San Bernardino plains.																							
Los Angeles.....	34 08	118 12	330	1872	1896	24	3.8	3.4	2.5	1.1	0.4	0.1	T.	0.1	0.1	0.7	1.5	3.6	17.2	40.5	5.6	235	83
San Fernando.....	34 16	118 26	1,066	1877	1891	14	2.4	3.2	2.7	1.6	0.4	0.1	T.	T.	0.1	0.7	1.4	3.2	16.0	37.0	5.4	231	34
San Bernardino.....	34 06	117 18	452	1870	1896	25	3.5	2.9	2.6	1.4	0.5	0.1	T.	0.2	0.1	0.6	1.5	3.2	16.6	37.2	5.6	224	34
Desert region.																							
Indio.....	33 49	116 14	20	1877	1896	16	1.0	0.5	0.2	T.	T.	T.	T.	0.2	T.	0.1	0.2	0.6	2.8	7.0	0.1	250	4
Mohave.....	35 03	118 11	2,751	1876	1896	17	0.9	1.0	0.8	0.2	T.	0.1	0.1	T.	0.1	0.2	0.2	1.4	5.0	15.9	0.3	318	6

The bulk of the rain and snow falls in the winter time, although there is no month in which rain or snow does not fall. The summer rains, however, are light, except on the west coast.

Rainfall of Oregon.—Here, as in Washington, the area of heavy rainfall is found on the coast, decreasing slightly from north to south. The rainfall in the narrow gorge where the Columbia River breaks through the Cascade Range is also heavy, but this is undoubtedly due to local causes. A similar case of very heavy precipitation at a single isolated station is that of Glenora, on the summit of the Coast Range, in Tillamook County, about 30 miles from the ocean. At this place the annual fall in 1896 was 169 inches, probably the greatest rainfall ever recorded in the United States in a single year. The annual average on the coast is about 70 inches, but the fall of individual years may be as much as 100 inches or as little as 35 inches.

In the lower and middle Willamette Valley the fall is about 46 inches; on the headwaters of the Willamette it is probably 40 inches or less. The fall decreases slowly to the southward, being 35 inches in Douglas County and a less amount in the mountainous region of the southern tier of counties. On the eastern slope of the Cascades the fall is about 20 inches; over the greater portion of the plateau region of central and eastern Oregon it is between 10 and 15 inches, rising to 15 and possibly 20 inches in northeastern Oregon.

The distribution by months is substantially the same as in Washington, with the single exception that the rainfall of summer is slightly less, except on the immediate coast.

CALIFORNIA.

Physical features.—The prominent topographic features of this State are the snow-clad range of the Sierra Nevada on the eastern border, the Coast Range on the west, and the Great Valley of California lying between.

Subordinate features, but nevertheless of importance in a study of the rainfall system, are the foothills of both mountain ranges, the desert region of southeastern California, the San Bernardino range of mountains, which forms the dividing line between the desert on the east and the western coast belt, and the San Jacinto Mountains, a southern extension of the San Bernardino range, passing out of the State in San Diego County.

The eastern slope of the Sierra Nevada falls away rather abruptly into the plateau region of Nevada. The western slope is less abrupt, and is cut into innumerable valleys and canyons, through which flow the tributaries of the principal rivers of the State—the Sacramento and San Joaquin. Besides the more prominent features of surface relief above mentioned, there is an infinite variety of smaller detail—an intermingling of mountain, valley, and plain, an adjustment of shore lines, land and water areas—all of which tend to modify and diversify the climate of different sections of the State.

The precipitation of California is almost wholly in the form of rain, except on the mountain slopes and summits. Snow rarely falls on the immediate coast as far south as San Francisco, and while not infrequent in the Great Valley it does not, as a rule, lie on the ground except for a short time.

In the lower foothills region, as in the valley, but little snow falls, yet a few thousand feet higher the snowfall is quite heavy and often covers the ground for weeks. The snowfall on the summits of the Sierra Nevada, where measurements have been made, averages about 30 feet in depth per annum—more than three times as much as has been recorded elsewhere in the United States. Snow falls on the mountains of southern California and occasionally on the desert on the leeward side of the higher mountain ranges.

But one snowstorm (that of February 5, 1887) has occurred at San Francisco during the last twenty-six years, although snow flurries are of occasional occurrence.

The average rainfall of California varies from 70 inches per annum at the northwestern corner to less than 3 inches on the Colorado desert, and the extremes of a single year may vary from zero on the desert to 120 inches in the foothills. There are two areas of heavy rainfall in the State, viz, the western face of the Coast Range north of San Francisco and the western flank of the Sierra Nevada range between latitude 38° and 40°. Smaller areas of comparatively heavy rainfall, surrounded by regions of lesser rainfall, may be found in Santa Cruz County and in San Diego County, the latter at an altitude of over 2,000 feet. The areas of least rainfall are the floor of the Great Valley and the desert country east of the Sierra Nevada and San Bernardino ranges.

TABLE V.—Monthly and annual averages, of precipitation, annual extremes, etc.—Continued.

Stations.	Latitude.	Longitude.	Elevation.	Record.		Whole years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.			Ratio.
				From—	To —														Mean.	Ex- tremes.		
																				Highest.	Lowest.	
IDAHO.	°	°	Feet.				In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	
Fort Sherman	47 42	116 38	2,198	1881	1896	13	3.7	2.3	2.2	1.8	2.0	1.4	0.5	0.4	1.3	1.9	3.5	8.5	24.5	38.0	14.1	114
Murray	47 33	115 52	.....	1893	1896	3	6.4	3.0	3.1	2.5	4.4	1.9	0.6	0.8	3.2	2.2	0.6	4.4	39.1	43.1	29.8	111
Boise City	43 34	116 08	2,768	1864	1896	27	2.3	1.4	1.7	1.3	1.6	0.8	0.2	0.2	0.4	0.9	1.3	2.1	14.2	25.8	6.7	182
Idaho Falls.....	43 30	112 04	4,781	1880	1896	6	2.2	1.7	2.0	1.5	1.2	1.1	0.5	0.6	0.7	1.0	1.2	1.5	15.2	21.3	8.6	142

The rains of most value to agriculturists in California are those of April and May, for however heavy the rains of winter may be, a failure of the spring rains generally brings disaster. The tables of monthly averages on page 28 show that points in the foothills region from 2,000 to 2,500 feet above sea level have a greater rainfall in April and May than points elsewhere situated having approximately the same annual mean. The immunity from absolute drought in that region is naturally a little greater than in other portions of the State. The character of the seasonal rainfall prior to April 1, whether light or heavy, early or late, as regards the setting in of the winter rains, affords no indication whatever of the amount of rain that may fall in April and May.

The variation in the rainfall of individual years and the fluctuations from the average are slightly greater on the Pacific Coast than elsewhere in the United States. The amounts of precipitation in the wettest and driest years, respectively, at 47 stations in Washington, Oregon, and California are given in Table V, and the relation of each amount to the general mean, expressed as a percentage, is given in the column headed "Ratio." The record of greatest amounts is of no especial significance, except as it may relate to the construction of storage reservoirs and irrigating systems. The record of least rainfalls, on the other hand, is believed to be useful as affording information upon the minimum amount of natural precipitation that may be expected.

On first thought it might be supposed that years of heavy rainfall would be counterbalanced by years of light rainfall, and that deviations of any given amount above or below the mean would be equally probable. This does not appear to be the case, but in order to more fully test the matter the records of 60 additional stations in California were examined. These gave an average for the wettest year of 77 per cent above the mean and for the driest year of 51 per cent below the mean. The average deviation at stations having approximately the same general mean was also determined, that it might be seen whether or not there is any definite ratio between the general mean and the amount of rain that falls in extraordinary periods of drought or heavy rainfall. The results are shown below, from which it appears that in droughty periods at least 50 per cent of the mean rainfall will be available, and this seems to be the case whether the latter is 20 or 40 inches.

Annual mean.	Number of stations.	Ratio of wettest year to general mean.	Ratio of driest year to general mean.
<i>Inches.</i>		<i>Per cent.</i>	<i>Per cent.</i>
0-10	9	210	50
10-20	23	191	51
20-30	7	171	51
30-40	8	165	52
40-50	5	168	52
50-60	8	156	51

The variance in the figures given in the column headed "Ratio of wettest year to general mean" was to be expected, since where the annual mean is of itself very small deviations therefrom which at stations having a greater fall would not be considered large appear to be unduly magnified. Moreover, when rain does fall at a station having a low annual average the rate of fall is very likely to approach that of adjacent points having a higher average.

The summer rainfall of California, even on the mountain tops, is practically *nil*, differing vastly in this respect from the rainfall system of Arizona. In the latter the mountain summits seem to contribute largely to the causes that produce the rainfall of summer. In California the mountains are not effective in causing rainfall during June, July, and August.

IDAHO.

Physical features.—There are but two grand divisions of surface relief in Idaho, viz: (1) The Bitter Root Mountains, whose crests form the eastern boundary of the State, and (2) the great lava-covered plains that extend westward and southward from the mountain slopes.

In the center of the State mountain spurs extend to the westward from the main mass, and even in the plains region isolated mountain groups extrude from the general surface. The known rainfall of the State is almost wholly that of the plains and valleys, the mountain rainfall being as yet practically unknown. Measurements made since 1893 at Murray (elevation about 3,000 feet), in the Oœur d'Alene section, indicate a heavy precipitation in winter, spring, and late fall, but

TABLE V.—Monthly and annual averages, of precipitation, annual extremes, etc.—Continued.

Stations.	Latitude.	Longitude.	Elevation.	Record.		Whole years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.			Ratio.	
				From—	To—														Mean.	Ex- tremes.			
																				Highest.	Lowest.		
UTAH.																							
Salt Lake City.....	40 46	111 54	4,354	1857	1896	29	1.6	1.6	2.1	2.0	2.0	1.1	0.9	1.3	1.0	1.6	1.5	2.0	18.8	38.0	10.2	203	55
Losee	37 38	112 03	.....	1889	1894	4	0.8	1.2	1.3	0.3	0.8	0.2	2.1	1.9	1.2	0.5	0.3	2.5	13.1	13.7	8.6	105	66
Terrace	41 32	113 33	4,548	1870	1896	22	0.6	0.4	0.5	0.4	0.6	0.2	0.1	0.1	0.3	0.1	0.3	0.7	4.3	10.0	0.7	233	16
Nephi	39 42	111 52	5,056	1883	1892	3	1.0	1.5	1.4	3.1	1.4	0.6	0.6	1.2	1.1	1.4	0.4	2.5	16.2	26.0	8.5	160	53
NEVADA.																							
Winnemucca.....	40 53	117 50	4,358	1870	1896	26	1.2	0.9	1.0	0.9	0.9	0.6	0.1	0.1	0.3	0.6	0.8	1.1	8.5	18.2	5.5	214	65
Pioche	37 56	114 26	6,110	1877	1893	10	0.9	1.3	1.2	0.9	0.8	0.4	0.5	1.3	0.4	0.5	0.4	2.0	10.6	27.4	5.3	258	50
Wells	41 07	114 56	5,628	1870	1895	24	1.5	1.0	1.0	0.6	0.8	0.5	0.2	0.2	0.2	0.5	0.8	0.4	7.7	17.3	3.4	225	44
Carson City.....	39 10	119 46	4,630	1875	1896	19	2.7	1.4	1.4	0.9	0.6	0.4	0.2	0.2	0.3	0.4	1.5	2.1	12.1	17.9	6.9	148	57

light in July and August. (See table.) The record of this station may be taken as a basis for the belief that the precipitation of the mountains is upward of 40 inches per annum. The fall on the plains is not, as a rule, sufficient for the needs of agriculture, but in the foothills region, where agriculture is practiced, the rainfall is generally sufficient to mature crops. Snow falls on the mountains to very great depths, and remains on the ground in secluded nooks throughout the year, thus furnishing a perennial supply of water to mountain streams.

The distribution of rain throughout the year is that which has elsewhere been described as the sub-Pacific type, viz, heavy winter and spring precipitation, with a minimum in July and August.

The fall is rather advantageously distributed for the purposes of irrigation, but the storage of the surplus waters of March and April would seem to be necessary at points far removed from the drainage basins of mountain streams.

NEVADA.

Physical features.—Nevada lies almost wholly within the Great Basin, on whose surface all of the rain that falls is either absorbed by the soil or evaporated under the intense insolation of the summer sun. No stream breaks through the barriers that arise on all sides, and but one (the Humboldt) flows across the State. The water that is drained from the eastern flank of the Sierras flows into saline lakes or is lost in the sands of the desert.

The precipitation is extremely light, as will be seen by the data of Table V, and the distribution throughout the year, the bulk of it falling during the winter, is not favorable to agriculture. The rainfall stations of Nevada are mainly on the lower levels, and but little account can, therefore, be taken of the rainfall of the mountain slopes and summits. Pioche, altitude 6,110 feet, in the southern part of the State, has an annual fall of but 10 inches. The average fall at Belmont, Nye County, altitude about 8,000 feet, is probably a little less than 10 inches. The last-named station is higher than the summit of the Sierra Nevada range at the crossing of the Union Pacific, where the average annual precipitation is 43 inches, but it is on the eastern flank of a mountain range of upward of 10,000 feet elevation, a position not favorable to precipitation.

In years of plentiful rainfall as much as 20 inches may fall at stations in the best-watered part of the State; in years of scant rainfall the amount may vary from zero in the southwestern part of the State to 6 or 7 inches in the region directly east of Lake Tahoe.

The summer maximum of rainfall in Arizona obtains in a measure throughout southern Utah and Nevada. Torrential downpours, locally known as "cloud-bursts," occasionally swell the mountain streams and gorges during the warm season.

The distribution of rain throughout the year closely follows the sub-Pacific type.

UTAH.

Physical features.—The eastern and southern parts of Utah lie within the drainage basin of the Colorado River; the northern and western portions lie within the Great Basin. The Wasatch range of mountains runs in a general north and south direction through the northern and central portions of the State. The drainage from the western slopes of this range is carried by numerous small streams flowing to the westward, whose waters eventually reach Great Salt Lake.

The rainfall of Utah is least in the northwestern part of the State, represented in Table V by Terrace, a station on the Central Pacific Railroad. The rainfall of the country immediately east and southeast of Great Salt Lake is undoubtedly heavier than it would be were the lake absent. The Wasatch Range is also a favorable condition to the precipitation of moisture on its western flank. South of the Great Basin, in Garfield and Iron counties, the rains of July and August are heavy, as in Arizona and New Mexico (see the record for Losee, Table V), and there is also a spring minimum which seems to indicate that the rainfall of southern Utah is closely related to the Arizona system.

Dependence is placed almost wholly upon irrigation in all parts of Utah where agriculture is practiced. In years of plentiful rainfall the amount of water available during the crop-growing season, April to August, in the best-watered part of the State, is not more than 8 or 10 inches, the bulk of which falls in April and May. On the other hand, in years of scant rainfall, as little as 2 inches may fall in the same region and during the same period. In the great majority of years not more than 5 or 6 inches may be expected.

TABLE V.—Monthly and annual averages, of precipitation, annual extremes, etc.—Continued.

Stations.	Latitude.	Longitude.	Elevation.	Record.		Whole years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.			Ratio		
				From—	To—														Mean.	Ex-tremes.				
																				Highest.	Lowest.			
ARIZONA.																								
Yuma.....	32 44	114 36	141	1875	1896	21	0.4	0.5	0.3	T.	T.	T.	0.1	0.3	0.1	0.3	0.3	0.5	2.9	5.9	0.7	211	25	
Prescott.....	34 33	112 28	5,318	1865	1896	25	1.5	1.3	1.6	0.8	0.9	0.1	2.8	3.0	1.2	0.9	0.9	1.3	16.8	26.7	10.9	159	60	
Phoenix.....	33 37	112 02	1,068	1876	1896	15	0.6	0.3	0.7	0.3	0.2	0.1	1.0	1.0	0.5	0.4	0.5	1.0	7.1	12.8	3.7	180	52	
Fort Apache.....	33 48	109 57	5,050	1878	1896	18	1.3	1.3	1.6	0.7	0.6	0.6	3.2	4.1	1.7	1.5	1.1	1.7	20.0	31.0	12.7	155	64	
Fort Grant.....	32 45	110 30	2,000	1873	1896	21	0.9	1.4	1.0	0.3	0.4	0.5	3.3	3.1	1.8	1.1	0.8	1.4	16.0	25.7	9.0	161	56	
Tucson.....	32 14	110 54	2,404	1875	1896	21	0.8	1.1	0.9	0.1	0.1	0.2	2.4	2.6	1.1	0.6	0.7	1.1	11.7	18.5	5.2	158	44	
NEW MEXICO.																								
Santa Fe.....	35 41	106 01	7,026	1850	1896	37	0.6	0.9	0.7	0.7	0.9	1.1	2.7	2.7	1.6	1.1	0.8	0.8	14.6	24.9	7.8	171	53	
Fort Stanton.....	33 29	105 38	7,500	1856	1895	19	0.6	0.8	1.0	0.6	1.0	1.7	3.2	3.8	2.1	1.4	0.8	1.0	18.0	23.8	11.3	160	63	
Fort Wingate.....	35 29	107 45	6,982	1864	1896	30	1.1	1.6	1.0	0.9	0.5	0.6	2.4	2.3	1.3	1.1	0.7	1.0	14.5	26.1	6.4	180	45	
Fort Bayard.....	32 46	108 30	4,450	1867	1896	20	0.7	1.1	0.5	0.4	0.3	0.6	3.2	2.7	1.8	1.1	0.7	0.8	13.9	20.3	5.7	146	41	
MONTANA.																								
Havre.....	48 32	109 42	2,472	1880	1896	16	0.9	0.5	0.5	1.0	1.7	3.1	2.1	1.4	1.2	0.6	0.7	0.5	14.2	25.5	9.8	180	60	
Fort Keogh.....	46 22	105 56	2,372	1877	1896	19	0.6	0.5	0.6	1.1	2.2	2.8	1.2	0.9	0.8	1.0	0.5	0.4	12.6	22.8	9.1	181	72	
Fort Maginnis.....	47 10	109 06	4,310	1882	1890	7	1.8	1.3	1.6	1.2	1.5	2.9	0.9	1.4	1.4	1.1	0.8	0.7	16.7	26.0	9.0	156	54	
Virginia City.....	45 10	112 00	5,600	1871	1896	16	0.6	0.6	1.0	1.2	2.7	2.3	1.4	1.2	1.3	0.8	0.7	0.8	14.6	22.4	7.1	153	49	

ARIZONA AND NEW MEXICO.

Physical features.—The mountain system of Arizona appears at the southeastern corner of the Territory, and extends in a general northwesterly direction to the borders of Utah and Nevada. More than half the Territory is above the 5,000-foot contour line, and forms a part of the great Plateau region west of the Rocky Mountains. About one-third of the Territory is sandy plain, gradually rising in elevation from less than 100 feet at Yuma to a rather narrow bench or mesa that faces the plains about 180 miles northeast of Yuma. The elevation of the mesa ranges from 3,000 to 5,000 feet above sea level. Beyond it to the northeast is the high plateau of Arizona.

New Mexico.—The Continental Divide enters New Mexico west of the Rio Grande River as a system of elevated plateaus and mountain ranges, and preserves its mountainous character to the Arizona line. The drainage of a considerable area of western New Mexico is into the Colorado through the Gila and San Juan rivers. The Rio Grande River cuts the Territory into two almost equal parts. The river valley is exceedingly narrow and is flanked on both sides by high mountains or elevated plateaus. The eastern third of the Territory partakes of the nature of the Great Plains, the northern portion draining into the Canadian and the southern into the Pecos, a tributary of the Rio Grande.

The rainfall of Arizona and New Mexico comes very largely in July and August, after the time of maturity of the staple crops. In Arizona the depth of fall varies almost directly with the elevation. The southwestern section receives less than 5 inches per annum; the mountain stations on the plateau from 16 to 20, according to elevation. Generally but very few points receive as much as 20 inches per annum on the average, while the greatest annual fall ever registered in the Territory was 35 inches, at old Camp Grant in 1871.

May and June and October and November are the months of least rainfall. The winter rains begin in December and practically end in March. They are more or less sporadic, and rarely as heavy as the summer rains. The latter are remarkably persistent and very rarely weakened during either July or August. Occasionally the rains may fail for one of the two months even at the higher level stations, but it seldom happens that there is a total failure in both months. At the lower levels—100 to 2,000 feet—failures are much more frequent. The summer rains seem to be largely the result of local convective action, and not altogether dependent upon the movement of areas of low pressure, as in the case of winter rains. There is, however, sufficient variation from year to year to lead to the belief that local convective action is not the sole cause.

MONTANA.

Physical features.—The western third of the State is greatly broken by mountain ranges running in a northerly and southerly direction. The eastern half of the State slopes from an altitude of nearly 5,000 feet to about 2,000 on the Dakota border. The State is well watered. Perennial streams, having their source in the western mountain ranges, flow eastward, eventually reaching the Missouri River.

The rainfall of Montana is most advantageously distributed for the purposes of agriculture, 33 per cent of the annual amount falling in May and June, and 67 per cent in the crop season, April to September, inclusive.

The average for the State is about 14 inches, that amount being common to all sections except the mountains, for which no information is available. Fragmentary observations indicate a greater amount in the northwestern part of the State and in the valley of the Yellowstone, where it enters the State from Wyoming.

Montana lies well within the track of atmospheric disturbances coming from the British possessions. The winter precipitation is light and principally in the form of snow; a portion of which, however, is evaporated by chinook winds and thus lost to the soil. The natural rainfall is generally insufficient for the needs of agriculture, although the deficit is not great except in years of very scant rainfall. Occasionally there is sufficient rainfall to mature crops, but since the years of abundance can not be foreseen the agriculturist must depend upon artificial watering to insure a return for his labor.

TABLE V.—Monthly and annual averages, of precipitation, annual extremes, etc.—Continued.

Stations.	Latitude.	Longitude.	Elevation.	Record.		Whole years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.			Ratio.		
				From—	To—														Mean.	Ex- tremes.				
																				Highest.	Lowest.			
WYOMING.																								
Fort Washakie.....	42 30	108 53	5,880	1880	1896	12	0.6	0.4	1.5	2.1	2.2	1.0	0.8	0.6	0.5	0.8	0.7	0.4	11.6	20.2	5.2	174	45	
Cheyenne.....	41 08	104 48	6,105	1870	1896	27	0.4	0.4	0.8	1.5	2.3	1.5	1.9	1.6	1.0	0.7	0.3	0.3	12.7	20.8	5.0	164	39	
COLORADO.																								
Mountain stations.																								
Pikes Peak.....	38 50	105 02	14,134	1873	1894	15	1.6	1.5	2.0	3.4	3.8	1.6	4.2	3.8	1.6	1.7	1.9	2.6	29.7	44.6	9.2	150	31	
Breckenridge.....	39 29	106 01	11,503	1889	1896	7	2.0	4.4	3.9	3.1	2.7	1.5	2.2	2.0	1.5	1.5	3.2	3.4	31.4	46.4	23.9	148	76	
Climax.....	39 20	106 15	10,304	1888	1896	6	3.4	4.1	5.0	3.4	3.3	1.3	3.0	2.6	1.3	1.9	2.4	3.1	34.8	45.0	20.2	129	58	
Foothills.																								
Fort Collins.....	40 35	105 02	5,000	1872	1896	10	0.7	0.6	0.8	1.7	2.9	1.7	1.8	1.3	0.9	0.9	0.4	0.3	14.0	18.1	7.1	129	51	
Denver.....	39 45	105 00	5,294	1870	1896	27	0.6	0.5	1.0	2.0	2.7	1.3	1.7	1.4	0.9	0.9	0.7	0.6	14.3	21.5	8.5	150	59	
Colorado Springs.....	38 51	104 47	6,032	1870	1896	12	0.2	0.3	0.6	1.4	2.4	1.9	3.2	2.2	1.1	0.6	0.3	0.3	14.5	18.5	8.6	128	59	
Las Animas.....	38 04	103 12	3,899	1881	1896	12	0.3	0.4	0.6	1.1	1.9	1.4	1.6	1.6	0.6	0.5	0.2	0.6	10.8	15.8	3.8	146	35	

WYOMING.

Physical features.—The general elevation of the surface of Wyoming is over 6,000 feet above sea level, a higher general average than for any other State except Colorado. The Continental Divide crosses the State diagonally in a general northwesterly and southeasterly direction. The Laramie Range, which enters from the south just west of Cheyenne, extends in a northerly direction for about 150 miles, thence westerly, merging into what is known as the Sweetwater Range. The Big Horn range occupies the northern central portion of the State, extending to the Montana line. These mountain ranges are the source of a number of perennial streams which give to Wyoming an excellent water supply. The precipitation is not sufficient for agricultural purposes, the annual fall of the plains being about 12 inches, of which nearly 70 per cent comes in the period April to September. April and May are months of comparatively heavy precipitation and occasionally heavy snowstorms. The precipitation of Yellowstone Park has been measured continuously since 1889. The average annual fall is 20 inches. Twenty-five inches per annum would, therefore, seem to be a fair estimate of the mountain precipitation of Wyoming.

COLORADO.

Physical features.—The Rocky Mountains reach their highest development in Colorado. Numerous peaks above 14,000 feet elevation abound, and almost half the State is furrowed by mountain ranges and spurs. West of the Continental Divide a number of short chains and spurs run northwest, west, and southwest, and beyond and between them a lofty plateau extends to the eastern rim of the Great Basin. East of the mountains the plains, with an average elevation of about 4,500 feet, slope away toward the Kansas line. The Divide, a low forest-covered ridge separating the waters of the South Platte on the north from those of the Arkansas on the south, extends eastward from the mountains 40 miles or more, and is probably 2,500 feet higher than the general surface of the plains.

The precipitation of winter in Colorado is almost wholly in the form of snow. On the lower levels and in the valleys it is light, but on the mountain slopes the fall is much heavier and may continue into April and May.

Atmospheric disturbances, passing north of Colorado, cause but little precipitation in the State except on the western slopes of the Continental Divide; when they pass through or south of the State, heavier precipitation results. It frequently happens, moreover, that the northwestern quadrant of the storm—the dry quadrant farther east—is wholly within the area of precipitation in both Colorado and Wyoming.

Although the annual precipitation of Colorado is small, it is distributed to the best advantage, and there are consequently a few localities, as on the Divide, where cereals may be grown without irrigation. Generally, however, and especially on the plains, the natural precipitation is insufficient for agricultural purposes.

The precipitation of the mountain region is shown by the group of three stations, Breckenridge, Climax, and Pikes Peak, while the eastern foothills region is represented by Fort Collins, Denver, and Colorado Springs. The last station in the group belongs to the plains rather than the foothills. The precipitation of the plains, and also of the parks, is less than in the foothills region. The summit of the Divide, and a narrow strip of territory on either side extending some distance eastward from the mountains, has a greater precipitation than adjacent areas. The rainfall of the mountain region, as will be seen by the tables, increases in July and August, as in New Mexico and Arizona.

TABLE V.—Monthly and annual averages, of precipitation, annual extremes, etc.—Continued.

Stations.	Latitude.	Longitude.	Elevation.	Record.		Whole years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.			Ratio.		
				From—	To—														Mean.	Ex- tremes.				
																				Highest.	Lowest.			
THE PLAINS AND MISSISSIPPI VALLEY.																								
North Dakota.																								
Fort Buford.....	48 00	103 55	1,900	1886	1896	29	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	169	53
Bismarck	46 47	100 38	1,677	1874	1896	22	0.6	0.6	1.1	2.3	2.5	3.5	2.3	2.0	1.2	1.0	0.8	0.6	0.6	13.8	23.3	7.3	168	61
Northern Minnesota.																								
St. Vincent	48 56	97 14	804	1871	1895	24	0.5	0.5	0.8	1.5	2.5	3.9	2.6	2.6	1.7	1.8	0.5	0.6	19.5	33.9	12.7	174	65	
South Dakota, southern Minnesota, and southern Wisconsin.																								
Fort Sully	44 39	100 39	1,600	1886	1894	25	0.5	0.4	1.2	2.1	2.6	3.3	2.7	1.9	0.9	0.7	0.4	0.5	17.2	24.0	12.1	140	76	
Fort Meade	44 26	103 28	3,624	1879	1896	16	0.8	0.5	1.4	2.8	3.5	3.3	1.9	1.7	0.6	0.9	0.7	0.6	18.7	27.1	13.1	145	70	
Yankton	42 54	97 28	1,234	1873	1895	20	0.6	0.8	1.2	3.3	4.0	4.1	3.5	3.0	2.6	1.3	0.6	0.8	25.8	40.9	19.8	159	77	
St. Paul	44 56	93 05	800	1859	1896	39	1.0	0.9	1.5	2.5	3.5	4.1	3.3	3.8	3.2	2.0	1.3	1.1	28.2	39.2	14.9	139	53	
La Crosse	43 49	91 15	744	1872	1896	24	1.2	1.1	1.5	2.4	3.3	4.5	4.0	3.2	4.2	2.3	1.6	1.4	30.7	45.0	17.4	141	57	
Madison	43 05	89 24	1,068	1869	1896	28	1.8	1.7	2.4	2.6	3.5	4.5	4.0	3.1	3.1	2.6	1.9	2.0	33.2	53.0	18.1	160	39	
Milwaukee	43 02	87 54	697	1841	1896	53	1.9	1.6	2.3	2.8	3.4	3.8	3.2	2.7	3.0	2.2	2.2	1.9	31.0	50.4	20.5	163	66	

THE PLAINS AND UPPER MISSISSIPPI VALLEY.

The eastern half of the Dakotas, Minnesota, Wisconsin, the northwestern part of Illinois, Iowa, Nebraska, Kansas, western Missouri, parts of Oklahoma, Indian Territory, and Texas are included in this designation. The general surface of the Plains proper has two slopes; the one upward toward the mountains, the other and more gradual one from the Panhandle of Texas northward and downward to the valley of the Missouri in North Dakota.

This region, by reason of its fertile and easily cultivated soil, is one of the most productive in the United States. The one great disadvantage is the variableness of its moisture supply.

In years of bountiful rain its western margin may be extended almost to the foothills of the Rocky Mountains; in years of average rain it is practically bounded by the ninety-eighth meridian, while in years of scant rainfall there may be partial failure of crops throughout its whole extent. So varied are its capabilities, however, that it rarely happens there is total failure of all crops except in the Far West.

There was a popular notion a few years ago that the rainfall of the plains was steadily increasing. Such an opinion was based, in all probability, upon the fact that from 1881 to 1885 heavy rains fell in parts of western Kansas and Nebraska and other portions of the subhumid region. A climatic change of such vast economic importance was naturally widely heralded. Several writers sought to account for the increase in various ways. It was generally believed that the great change that had been wrought in the general land surface during the thirty years previous was an effective cause in producing heavy rains. The prairie sod had been broken up and many thousands of acres had been put under cultivation. Much of the rain that once ran into the natural drainage channels was now absorbed by the soil, and the opportunities of local evaporation were thus greatly increased.

The fact remained, whatever the theories, that there was rain in moderate abundance where heretofore had been drought and insufficient moisture.

It will, perhaps, clarify our ideas on the subject if we examine in some detail the vicissitudes of rainfall both on the Plains and elsewhere. We shall possibly find that rainfall is not altogether a lawless phenomenon, and that useful conclusions may be drawn from the observations that have been made during the past quarter century. For this purpose the table below has been prepared. Column 1 shows the name of the station; column 2, the number of years of observation; column 3, the mean annual fall; column 4, the maximum or wettest year of the whole period expressed as a percentage of the mean fall; column 5, the percentage of the two wettest consecutive years, column 6, the three wettest consecutive years; columns 7, 8, and 9, the percentage, respectively, of the single driest, the two driest consecutive years, and the three driest consecutive years; columns 10 and 11, the largest number of consecutive years with precipitation above the mean and the percentage, respectively; columns 12 and 13, the largest number of consecutive years with precipitation below the mean and the percentage, respectively; column 14, the percentage of the number of years with precipitation above the mean and the average percentage of all such years; and finally, in column 16, the percentage of all of the years below the mean.

TABLE V.—Monthly and annual averages, of precipitation, annual extremes, etc.—Continued.

Stations.	Latitude.	Longitude.	Elevation.	Record.		Whole years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.			Ratio.				
				From—	To—														Mean.	Highest.	Ex- tremes.					
																					Lowest.					
THE PLAINS AND MISSISSIPPI VALLEY—cont'd.																										
Nebraska.																										
North Platte	41 08	100 45	2,841	1866	1896	29	0.4	0.4	0.7	2.1	3.0	3.5	2.5	2.3	1.5	0.8	0.4	6.5	18.1	30.1	10.1	167	56			
Genoa	41 25	97 40	1,585	1875	1896	21	0.9	0.8	1.2	2.9	4.1	4.5	3.9	2.5	2.8	1.5	0.8	0.9	26.8	37.5	15.4	140	57			
Omaha	41 16	95 56	1,113	1870	1896	27	0.7	0.7	1.5	3.1	4.5	5.3	4.6	3.3	3.0	2.6	1.1	1.0	31.4	48.8	17.8	155	57			
Iowa.																										
Cresco	43 22	92 07	1,855	1871	1896	25	1.3	0.9	1.8	2.6	3.8	5.0	3.9	2.8	3.6	2.3	1.5	1.4	30.9	43.9	22.7	142	73			
Monticello	42 13	91 15	880	1855	1896	42	1.6	1.7	2.4	2.6	3.9	4.5	4.2	3.7	3.8	2.8	2.3	2.3	35.8	52.2	18.6	146	52			
Ames	42 03	93 38	1,000	1869	1896	21	1.0	0.8	1.6	2.9	4.1	4.4	4.7	3.4	3.6	2.3	1.3	1.1	31.1	51.1	20.7	164	67			
Davenport	41 30	90 38	615	1870	1896	26	1.7	1.6	2.2	2.8	4.2	4.2	3.6	3.6	3.2	2.6	2.0	1.6	33.3	46.8	18.5	141	56			
Illinois.																										
Marengo	42 15	88 37	842	1850	1896	45	1.9	1.9	2.4	2.8	3.9	4.3	3.7	3.7	3.8	2.4	2.2	1.9	35.2	56.9	24.0	162	68			
Chicago	41 54	87 38	600	1867	1896	30	2.1	2.2	2.4	3.0	3.7	3.7	3.4	2.9	3.0	2.7	2.7	2.2	34.0	45.8	22.4	135	66			
Peoria	40 42	89 36	475	1855	1896	41	1.7	2.0	2.6	3.2	3.8	3.7	4.0	3.0	3.5	2.4	2.4	2.3	34.6	53.4	23.6	154	68			

TABLE VI.—*Variation in annual rainfall.*

Stations.	Years of record.	Mean.	Ratio of the wettest years to the general mean.			Ratio of the driest years to the general mean.			Number of years and average fall during longest series of consecutive years above and below the average.				Percentage of years above.	Average fall of all the years.	
			Single wettest year.	Two wettest consecutive years.	Three wettest consecutive years.	Single driest year.	Two driest consecutive years.	Three driest consecutive years.	Years above.		Years below.			Above.	Below.
									Num-ber.	Aver-age.	Num-ber.	Aver-age.			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
ILLINOIS.															
Cairo.....	25	Inches. 42.6	Per ct. 144	184	129	62	75	75	4	121	5	83	44	121	83
Marengo.....	45	35.2	162	156	144	68	70	80	4	140	6	84	44	119	85
Peoria.....	41	34.6	164	122	117	68	80	85	5	115	3	85	49	115	86
IOWA.															
Cresco.....	25	30.9	142	133	128	74	78	82	7	120	4	90	48	117	85
Davenport.....	26	33.3	139	122	115	55	68	72	6	111	4	76	52	114	83
Monticello.....	42	35.8	146	140	127	52	62	67	3	127	6	86	45	120	84
Logan.....	27	34.2	164	137	127	49	58	63	5	122	4	84	48	121	81
NEBRASKA.															
Omaha.....	27	31.4	154	152	141	56	62	69	5	136	5	70	48	122	77
North Platte.....	29	18.1	164	130	129	61	66	71	3	116	3	71	48	123	78
KANSAS.															
Dodge City.....	22	19.8	171	149	140	52	58	72	3	140	3	72	38	139	77
EASTERN STATES.															
Albany, N. Y.....	68	39.5	144	142	132	71	82	83	4	126	8	91	41	114	90
Boston, Mass.....	79	45.4	149	143	136	60	72	79	14	123	7	86	53	113	85
New Bedford, Mass.....	83	43.5	141	132	130	71	80	82	9	113	9	86	45	115	88
New York, N. Y.....	61	44.7	147	132	127	62	74	76	11	122	8	84	43	119	86
Washington, D. C.....	41	42.9	142	130	124	71	75	78	5	114	5	90	48	115	86
Savannah, Ga.....	48	50.4	147	132	121	67	78	78	3	121	7	90	40	120	87

THE WETTEST YEAR.

In the case of Illinois, three stations are given; Cairo, in the extreme southern part of the State, with a record of twenty-five years; Peoria, in the north-central portion, and Marengo, in McHenry County near the Wisconsin line, with records extending over forty years in each case. The first-named station has the largest annual mean and the ratio of the wettest year to the mean is least, viz: 1.4: 1. It is possible that a continuation of the observations over a larger period may raise the ratio, but, generally speaking, the greater the annual fall the less the ratio of the wettest year. The remaining stations, Peoria and Marengo, have ratios of 1.6: 1 and 1.5: 1, respectively, and since observations have been carried on uninterruptedly for over forty years, it is reasonable to assume that the fall in the wettest year in Illinois will not greatly exceed about 160 per cent of the mean fall. Proceeding westward to the region of small annual fall, we find at North Platte, Nebr., and Dodge City, Kans.—the outposts of the subhumid region—the ratio of the wettest year to the general mean much higher than in Illinois or other portion of the region under consideration. To test the matter still further, the ratio of the rainfall of the wettest year to the mean at 66 stations throughout the United States was computed. The results are given in the table below, from which it appears the variations noted in the rainfall of the Plains are common to the whole of the United States. In other words, an annual rainfall equaling about 170 per cent of the mean is to be expected once or more in a term of years at all places having a mean fall between 5 and 30 inches. The occurrence of one or more years of heavy rain should not therefore be considered as a permanent change in the rainfall, but rather as a fulfillment of one of the natural conditions of rainfall phenomena. Three consecutive years of rain averaging slightly over 140 per cent of the mean fall have occurred in Kansas, Nebraska, and Illinois. (See columns 5 and 6, Table VI.)

Ratio of wettest and driest years to the mean fall.

Mean fall.	Number of stations.	Average of wettest year.	Average of driest year.
Inches.		Per cent.	Per cent.
50-60	7	142	70
40-50	23	143	64
30-40	21	154	64
5-30	15	178	55

TABLE V.—Monthly and annual averages, of precipitation, annual extremes, etc.—Continued.

Stations.	Latitude.	Longitude.	Elevation.	Record.		Whole years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.			Ratio.	
				From—	To—														Mean.	Ex- tremes.			
																				Highest.	Lowest.		
THE PLAINS AND MISSISSIPPI VALLEY—cont'd.																							
Kansas.																							
Dodge City.....	37 45	100 00	2,512	1874	1896	22	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	170	51
Lawrence.....	38 58	95 14	849	1861	1896	31	1.2	1.4	2.3	3.2	4.6	5.0	4.7	3.9	3.5	2.7	1.8	1.6	35.9	47.2	24.2	131	67
Independence.....	37 13	95 41	794	1872	1896	25	1.6	2.0	2.2	3.7	4.6	4.9	4.2	3.0	3.7	2.7	1.8	2.3	36.7	55.0	26.6	150	72
Missouri.																							
Oregon.....	40 02	95 09	1,100	1855	1896	41	1.6	1.8	2.0	3.3	4.7	4.7	4.3	4.3	3.1	2.6	1.7	1.6	35.8	49.4	22.2	138	62
Miami.....	39 18	93 15	640	1847	1896	49	1.7	1.7	2.4	3.0	4.2	5.0	4.2	3.6	3.4	2.8	2.1	2.0	36.1	58.3	15.6	161	43
St. Louis.....	38 37	90 12	481	1836	1896	60	2.2	2.7	3.4	3.7	4.7	5.0	3.8	3.5	3.1	2.8	3.1	2.8	40.8	68.8	22.6	169	55
Northern Texas, Oklahoma, and Indian Territory.																							
Fort Elliott.....	35 30	100 21	2,650	1879	1896	11	0.6	0.5	0.6	2.6	4.4	3.2	2.3	3.3	1.8	2.5	0.6	0.7	23.1	36.9	15.5	160	67
Silver Falls (Mount Blanco).....	33 35	101 06	3,800	1886	1896	7	0.8	1.0	0.4	2.1	1.5	2.2	2.2	2.2	1.6	1.8	0.8	0.6	16.4	19.8	10.5	121	64
Fort Sill.....	34 40	98 23	1,200	1870	1896	24	1.2	1.2	1.5	2.7	4.4	3.7	2.9	3.2	2.8	2.7	1.5	1.9	29.7	48.5	17.1	163	58
Fort Gibson.....	35 50	95 20	510	1836	1890	29	2.1	2.2	2.5	4.1	4.5	3.9	2.7	2.8	2.7	3.4	2.9	2.1	35.9	55.8	18.8	155	52

THE DRIEST YEAR.

The percentages given in columns 7, 8, and 9 show that the ratio between the mean fall and the fall of the driest year is more constant than that which subsists between the mean fall and the fall of the wettest year. The tendency, however, is toward a diminished ratio as dry regions are approached. Note also the close agreement between the ratios at Dodge City, Kans., and North Platte, Nebr. It is a significant fact that for a period of three consecutive years the precipitation at these places was but 70 per cent of the average.

The statistics given in columns 10, 11, 12, and 13 are merely amplifications of the subject-matter of the preceding paragraphs, and will be understood without further explanation.

That years of precipitation above the mean are less frequent than years with precipitation below the mean can easily be seen by an inspection of the data in column 14.

The foregoing may be summarized as follows: (1) Extremes of precipitation bear a rather definite relation to the general mean, the ratio being less the greater the mean and vice versa. Thus in a region of moderate rainfall, say 45 inches per annum, the probability is that in the year of maximum fall the amount will not be greater than about 140 per cent of the mean and not less than about 65 per cent in the year of least rain. The importance of this principle lies in the fact that once the mean fall is established the extremes may be roughly determined by calculation; (2) there may be from three to six and even a greater number of consecutive years with precipitation above or below the general mean, and (3) this condition obtains alike in all parts of the United States; (4) as a general rule, years with precipitation above the mean are less frequent than years below the mean, and the overplus is a little greater than the deficiency.

The annual variation of rainfall in the middle Mississippi Valley from 1858 to 1896 is given in the table of progressive averages, page 20. The record begins with a period of abundant rainfall in the early sixties, followed by a period of rather even distribution until the drought of 1870; then follows a period of eleven years, 1875-1885, with abundant rain, since which time, with the possible exception of 1892, there has been a general deficiency. These figures would seem to indicate a return to a period of greater rainfall.

TABLE V.—Monthly statement and annual averages, of precipitation, annual extremes, etc.—Continued.

Stations	Latitude.	Longitude.	Elevation.	Record.		Whole years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.			Ratio.	
				From—	To—														Mean.	Highest.	Lowest.		
GULF STATES AND TEXAS.																							
Shreveport.....	32 30	93 40	249	1871	1896	25	4.7	4.2	4.6	5.2	4.2	3.7	3.4	2.1	3.7	3.2	4.7	4.5	48.2	66.5	32.1	138	67
Montgomery.....	32 23	86 18	219	1870	1896	24	5.4	5.4	6.4	4.8	4.0	4.7	4.6	4.0	2.9	2.3	3.4	4.5	52.5	69.8	39.7	133	76
Mobile.....	30 41	88 02	69	1870	1896	26	5.1	4.8	7.6	4.6	4.3	5.9	6.7	6.8	5.0	3.4	3.9	4.5	62.6	90.9	42.6	145	68
New Orleans.....	29 58	90 04	52	1870	1896	26	5.1	4.4	5.3	5.2	4.8	6.7	6.4	6.0	4.6	3.3	4.1	4.4	60.3	85.6	38.7	142	64
Corsicana.....	32 04	96 27	445	1874	1896	17	3.1	2.7	2.8	4.3	5.4	3.3	2.4	1.9	2.6	2.5	3.6	2.9	37.5	53.9	28.1	144	75
Galveston.....	29 18	94 47	44	1871	1896	26	3.6	3.0	2.9	2.8	3.7	4.9	3.1	5.3	6.0	4.2	4.3	3.9	47.7	67.0	23.7	140	50
Austin.....	30 17	97 44	650	1856	1896	30	2.2	2.4	2.5	3.0	4.2	2.7	1.8	2.7	4.2	2.7	2.7	2.3	33.4	51.9	18.4	155	55
Rio Grande City.....	26 27	98 47	230	1849	1896	35	1.1	0.9	0.9	1.2	2.5	2.5	1.4	2.6	3.4	1.9	0.9	1.0	20.3	32.1	9.4	158	46
Fort Davis.....	30 38	103 56	4,928	1855	1891	20	0.5	0.4	0.4	0.6	1.0	1.7	3.3	3.8	3.0	1.4	0.5	0.4	18.1	26.4	8.6	146	48
Fort Bliss and El Paso.....	31 47	106 30	3,796	1850	1896	33	0.4	0.5	0.3	0.1	0.3	0.5	1.6	1.9	1.6	0.8	0.5	0.4	8.9	21.9	2.8	246	31
Lower Mississippi Valley.																							
Nashville.....	36 09	86 49	533	1839	1896	32	5.0	5.0	5.2	4.7	3.9	4.3	4.3	3.6	4.1	2.7	3.9	3.5	50.2	67.3	33.6	134	67
Memphis.....	35 09	90 03	330	1871	1896	26	5.5	5.2	5.9	5.4	4.4	4.6	3.4	3.5	3.1	2.7	4.8	4.1	52.6	73.4	35.0	140	67
Vicksburg.....	32 23	90 50	350	1840	1896	42	5.3	4.9	5.5	5.3	4.4	3.9	4.5	3.4	3.3	2.6	4.7	4.9	52.7	84.3	37.1	160	70
SOUTHERN ATLANTIC STATES AND FLORIDA.																							
Wilmington.....	34 14	77 57	52	1871	1896	26	3.8	3.3	3.9	2.9	4.2	5.7	7.1	7.3	6.3	3.8	2.4	3.0	53.7	83.7	40.4	156	75
Lenoir.....	36 00	81 28	1,186	1871	1896	25	4.2	4.3	3.9	3.5	4.8	4.1	5.1	5.7	4.6	3.3	3.3	3.6	50.4	65.6	41.5	130	82
Charleston.....	32 47	79 56	15	1738	1896	89	3.0	2.9	3.5	2.4	3.6	4.8	6.0	7.2	5.7	3.3	2.4	3.1	49.1	78.4	23.7	160	48
Kirkwood.....	34 17	80 33	232	1866	1891	32	3.3	3.2	3.9	3.1	3.6	3.9	5.2	5.3	3.9	2.5	2.5	3.5	43.9	54.6	30.1	124	69
Augusta.....	33 28	81 54	183	1870	1896	27	4.5	4.0	5.1	3.4	3.4	4.6	5.4	5.0	3.7	2.5	3.0	3.4	48.0	57.1	39.3	119	81
Fort Brook.....	28 00	82 28	20	1840	1896	24	2.5	2.8	3.0	1.9	2.9	7.6	9.8	9.5	6.2	2.4	2.0	2.3	53.1	89.9	36.0	169	68
Jacksonville.....	30 20	81 39	43	1870	1896	27	3.1	3.0	3.6	2.7	3.8	6.1	6.2	6.7	8.2	5.2	2.7	2.8	54.1	82.1	40.2	152	74
Key West.....	24 33	81 49	10	1833	1896	49	2.1	1.6	1.6	1.2	2.9	4.5	3.8	5.0	6.6	5.0	2.0	1.9	38.2	71.1	20.5	186	54
APPALACHIAN REGION AND TENNESSEE.																							
Knoxville.....	35 56	83 58	980	1870	1896	26	5.3	5.3	5.4	4.9	4.0	4.2	4.4	4.0	2.7	2.7	3.8	3.9	50.6	73.8	37.4	146	74
Chatanooga.....	35 04	85 15	783	1879	1896	18	6.4	5.6	5.8	4.5	4.1	4.7	4.1	4.1	3.7	2.6	4.0	4.3	53.9	68.1	37.2	128	69
Charlotte.....	35 13	80 51	808	1878	1896	18	4.9	4.4	4.5	3.4	4.1	4.5	5.6	5.1	3.5	3.6	3.0	4.0	50.6	68.4	34.8	135	69
Murphy.....	35 05	84 02	1,580	1872	1896	16	6.2	6.3	6.0	5.0	3.2	5.4	6.5	5.3	3.5	3.1	4.5	5.2	60.2	79.8	45.6	133	76

a Combined with Fort Ringgold.

GULF STATES AND TEXAS.

The States bordering on the Gulf, Texas alone excepted, have an abundant rainfall at all seasons of the year. The precipitation of the eastern third of Texas is also amply sufficient for the needs of successful agriculture, but there is a large extent of territory stretching from the one hundred and first meridian to the western borders of the State, the rainfall of which is precarious and generally insufficient for the growth and maturity of crops. The distribution of rain in western Texas, as at El Paso, is similar to that of New Mexico, viz, a maximum in July and August, but the total rainfall is so small that it is immaterial when it comes.

The rains of northern Texas, including the Panhandle, are distributed throughout the year in accordance with the Plains system hereinbefore described. The rainfall on the immediate coast of Texas is subject to tremendous variations, especially during September and October. Thirty inches have been recorded in a single month, and again merely a trace has fallen. Under these conditions it will require a great many years to determine the true average fall of the different months. The diminution in the fall of coast stations, referred to on page 19, is perhaps without a parallel in the rainfall records of the United States. It may or may not be a significant fact that the provinces of India which suffered drought in 1895 and 1896 are in about the same latitude as Texas, but here the analogy ends; the rainfall of India in 1893-94 was abundant, whereas there was a general deficiency in corresponding latitudes in the United States.

Little can be said of the rainfall of the Gulf States that will add to the information contained in Table V. There is a fringe of coast line extending from the neighborhood of the mouth of the Mississippi to the middle of the Florida Peninsula that has an annual fall of 60 inches and over. The decrease inland and northward, however, is rapid, the registers of Vicksburg and Montgomery, the latter less than 150 miles from the coast, showing a diminution in fall of about 8 inches per annum.

The rainfall of winter and spring is largely due to the passage of atmospheric disturbances having their origin on the plains of Texas. The rainfall of summer is more or less independent of the movement of cyclonic storms and appears to be determined largely by local conditions of heat and moisture.

LOWER MISSISSIPPI VALLEY.

For all practical purposes, the rainfall system of the Lower Mississippi Valley may be classed with Gulf types, the chief point of difference between the two being the absence of the heavy midsummer rains of the coast region. The distribution throughout the year is quite uniform, and there is generally an abundance of rain for all purposes. The months of least rain are September and October, a period when much rain is not desirable for obvious reasons.

THE SOUTH ATLANTIC STATES AND FLORIDA.

This is also a region of abundant rainfall whose distinguishing characteristic is a period of heavy rains in July and August which, in lower latitudes, extends into September. A portion of the increased fall of these months is due to the occasional visitation of this region by West India hurricanes; but the chief cause seems to be related in some manner to the ocean. The oceanic influence, or whatever it may be, is manifested on the Atlantic Coast from Norfolk to Key West, and from that point westward, following the trend of the Gulf Coast beyond the limits of the United States. The profiles of stations 150 miles inland show little, if any, evidence of a midsummer maximum, but it is plainly observed at all coast stations.

The rainfall of the South Atlantic States is fairly uniform throughout the year, thus furnishing an abundance of water power in the various rivers that drain its watersheds.

SOUTHERN APPALACHIAN AND TENNESSEE.

The rainfall system of the southern portion of the Appalachian Range and adjacent portions of North Carolina and Tennessee is characterized by heavy midsummer and winter precipitation, with intervening periods of lighter rains. There is sufficient rain in the crop-growing season, on the average, for all needs. Many important rivers have their source in the mountain regions of Tennessee and North Carolina, some flowing to the Atlantic, some direct to the Gulf, and the water of others ultimately reaches the Gulf via the Mississippi.

The rainfall on the southeastern slopes of the Appalachian Range in North Carolina is probably the heaviest east of the Sierra Nevada Range.

TABLE V.—Monthly and annual averages, of precipitation, annual extremes, etc.—Continued.

Stations.	Latitude.	Longitude.	Elevation.	Record.		Whole years.	Annual.												Ratio.				
				From—	To—		January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.		Mean.	Ex- tremes.		
																					Highest.	Lowest.	
LAKE REGION.																							
Duluth.....	46 47	92 06	702	1870	1896	26	1.1	1.1	1.6	2.5	3.7	4.5	3.6	3.3	3.7	2.6	1.7	1.3	30.7	45.3	20.0	148	65
Marquette.....	46 34	87 24	734	1857	1896	33	2.1	1.9	1.9	2.3	2.9	3.4	2.9	2.9	3.6	3.1	2.8	2.4	32.3	42.9	22.3	133	69
Grand Haven.....	43 05	86 13	620	1871	1896	25	2.5	2.1	2.3	2.6	3.4	3.8	2.8	2.7	3.6	3.2	3.0	2.6	34.6	47.9	24.1	138	70
Lansing.....	42 44	84 26	841	1864	1896	33	1.8	2.0	2.3	2.4	3.4	4.0	3.1	2.7	2.9	2.5	2.4	2.1	31.6	48.5	22.8	153	72
Detroit.....	42 20	83 03	597	1836	1896	46	2.0	1.9	2.5	2.6	3.1	3.8	3.6	2.6	3.0	2.6	2.6	2.2	32.5	47.7	21.1	147	65
Cleveland.....	41 30	81 27	643	1855	1896	41	2.5	2.6	2.7	2.7	3.5	3.9	3.4	3.1	3.6	2.8	3.1	2.7	36.6	53.6	26.0	146	71
OHIO VALLEY.																							
Pittsburg.....	40 32	80 02	847	1836	1896	54	2.6	2.5	2.8	3.0	3.5	3.6	4.0	3.4	2.9	2.8	2.6	2.9	36.6	50.7	25.8	189	70
Marletta.....	39 28	81 26	580	1817	1896	69	3.1	3.1	3.2	3.3	3.9	4.1	4.4	3.9	3.1	3.1	3.1	3.4	41.7	61.9	17.8	148	43
Cincinnati.....	39 06	84 30	580	1835	1896	62	3.3	3.3	3.5	3.3	4.0	4.4	3.9	3.8	3.0	2.8	3.3	3.5	42.1	65.3	25.3	155	60
North Lewisburg.....	40 12	83 32	1,090	1872	1896	25	3.6	3.5	3.2	3.1	3.9	4.0	4.4	3.3	3.2	2.2	3.3	2.8	40.5	49.5	23.3	122	58
Indianapolis.....	39 46	86 10	753	1870	1896	27	2.9	3.4	3.6	3.6	4.0	4.5	4.2	3.3	3.1	2.8	3.8	3.0	42.2	57.5	25.1	136	59
Louisville.....	38 15	85 45	530	1841	1896	54	3.7	4.0	4.4	4.2	4.1	4.7	4.1	3.8	3.0	2.9	3.9	4.4	47.2	67.0	30.9	142	65
Cairo.....	37 00	89 10	377	1871	1896	25	3.7	3.9	3.8	3.8	4.1	4.4	3.4	2.8	2.6	2.7	4.2	3.2	42.6	61.5	26.6	144	62
MIDDLE STATES.																							
New Brunswick.....	40 30	74 27	48	1854	1896	43	3.8	3.6	3.8	3.7	3.9	3.9	4.7	4.9	3.8	3.4	3.7	3.5	46.7	61.2	33.2	131	71
Philadelphia.....	39 57	75 06	117	1825	1896	72	3.2	3.1	3.4	3.4	3.8	3.8	4.0	4.3	3.5	3.2	3.3	3.3	42.3	61.2	29.5	145	70
New York City.....	40 42	74 02	159	1836	1896	61	3.4	3.4	3.7	3.4	4.0	3.8	4.0	4.7	3.4	3.6	3.7	3.6	44.7	65.5	27.6	147	62
Ithaca.....	42 27	76 30	417	1828	1896	36	2.0	1.9	2.3	2.2	3.4	3.7	3.5	3.0	3.0	2.9	2.6	2.2	32.7	46.3	16.5	142	50
Plattsburg Barracks.....	44 41	73 26	186	1840	1896	35	1.7	1.5	2.0	1.8	2.6	3.0	3.4	3.3	2.9	2.8	2.4	2.0	29.5	43.9	19.0	149	64
Cumberland.....	39 39	78 45	700	1871	1896	24	2.1	2.6	2.9	2.5	3.4	3.8	3.4	3.2	2.8	2.3	2.2	2.1	33.3	52.5	22.5	158	68
Washington.....	38 54	77 03	115	1856	1896	41	3.4	3.1	3.9	3.4	4.1	3.9	4.5	4.0	3.5	3.3	2.7	3.1	42.9	61.3	30.7	143	72
Lynchburg.....	37 25	79 09	658	1871	1896	26	3.8	3.6	3.8	3.3	4.0	3.5	4.1	3.9	3.9	3.2	3.1	2.9	43.1	60.5	30.6	140	71
Birds Nest.....	37 25	75 52	40	1869	1896	27	3.8	4.0	5.0	3.7	4.0	3.2	4.7	4.6	3.7	3.8	3.0	3.6	47.1	71.2	33.4	151	71

LAKE REGION.

The Lake region is the great highway of atmospheric disturbances that enter the borders of the United States from the west or northwest or form on the plains east of the Rocky Mountains and in the Gulf region, and advance toward the St. Lawrence Valley.

The annual precipitation is between 30 and 35 inches, being slightly heavier on the east and south than on the north and west sides of the lakes. The distribution throughout the year is much similar to that of the Plains, the maximum occurring in the crop-growing season. There is a secondary maximum in September almost equal in magnitude to the primary one in June.

OHIO VALLEY.

The precipitation of the Ohio Valley differs from that of the Lake region principally in quantity and evenness of distribution. The precipitation of winter is considerably heavier and often in the form of rain, whereas that of the Lake region, especially the upper lakes, is generally in the form of light snow.

MIDDLE STATES.

The precipitation of this region is uniformly distributed throughout the year, and there is sufficient, on the average, for the needs of commerce and agriculture. Its geographic position is favorable to moderate precipitation at all seasons, being almost in the direct course of atmospheric disturbances, whether advancing from the southwest or by way of the Lake region.

TABLE V.—Monthly and annual averages, of precipitation, annual extremes, etc.—Continued.

Stations.	Latitude.	Longitude.	Elevation.	Record.		Whole years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.			Ratio.	
				From—	To—														Mean.	Ex- tremes.			
																				Highest.	Lowest.		
NEW ENGLAND STATES.																							
	°	°	Feet.				In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	
New Haven.....	41 18	72 56	45	1804	1896	45	3.8	4.0	3.8	3.3	3.9	3.1	4.5	4.6	3.8	3.8	3.8	3.4	45.9	59.9	33.9	131	74
Springfield.....	42 38	72 35	120	1848	1896	47	3.5	3.5	3.5	3.2	4.2	3.8	4.5	4.5	3.4	4.2	3.8	3.5	45.6	58.0	30.8	127	68
Hartford.....	41 25	72 40	60	1870	1896	27	4.3	4.0	4.2	3.0	3.6	3.0	4.1	4.6	3.2	3.9	3.8	3.6	45.3	59.0	35.5	130	78
New Bedford.....	41 39	70 56	100	1814	1896	83	3.7	3.6	4.0	3.6	3.8	3.0	3.1	3.9	3.3	3.7	4.0	3.6	43.5	61.2	30.8	141	71
Gardiner.....	44 14	69 48	76	1837	1896	53	3.6	3.5	3.9	3.4	3.6	3.2	3.2	3.6	3.2	4.1	4.0	3.6	43.3	55.4	30.2	128	70
Strafford.....	43 52	72 25	50	1873	1896	24	3.4	2.9	3.3	2.5	3.3	3.5	4.1	3.7	3.4	3.1	3.4	3.2	39.8	51.3	28.9	129	73
Concord.....	43 12	71 33	252	1853	1896	42	3.1	2.8	3.3	2.6	3.3	3.1	3.7	3.9	3.4	4.1	3.5	3.0	39.8	54.4	27.6	137	69
Lunenburg.....	44 28	71 41	850	1848	1891	44	3.0	2.8	3.3	2.6	3.6	3.5	3.9	3.8	3.4	3.5	3.2	2.9	39.6	60.8	29.8	154	75
Burlington.....	44 28	73 12	346	1828	1896	53	1.9	1.5	1.8	1.9	3.1	3.2	4.0	3.6	3.5	3.8	2.6	1.9	32.7	49.4	21.0	151	64
Boston.....	42 21	71 04	18	1818	1896	79	3.8	3.5	4.1	3.8	3.7	3.2	3.6	4.3	3.4	3.8	4.3	3.9	45.4	67.6	27.2	149	60
Providence.....	41 49	71 24	11	1832	1896	65	4.1	3.8	4.1	3.7	3.8	3.8	3.3	4.2	3.2	3.8	4.2	3.9	45.4	63.5	30.6	140	68

NEW ENGLAND.

Physical features.—The surface of New England is broken and irregular, a mountain system of considerable extent traversing the States of Vermont, New Hampshire, and Maine, with a southerly extension of the Green Mountains of Vermont into western Massachusetts. Isolated peaks reach an altitude of 3,500 feet in western Massachusetts; 4,300 feet in Vermont; 6,300 feet in New Hampshire, and 5,300 feet in Maine. The general surface of the range in western Massachusetts is 1,200 to 1,600 feet above sea level; in Vermont, 1,500 feet; in New Hampshire, 2,000 feet, and in Maine from 1,500 to 2,000 feet.

While the mountain system of New England does not greatly modify the rainfall conditions, it plays an important part in the water supply of the towns and cities that cluster along the larger rivers. Virgin forest covers in great part the mountain slopes over a considerable area, thus conserving to a certain extent the rains of summer and the snows of winter. Numerous lakes throughout Maine and New Hampshire serve as natural reservoirs for the storage of flood waters, and tend to maintain a steady flow of water in the rivers below.

The manufacturing industries of New England are largely dependent upon the water power furnished by her rivers. The question of water supply, while possibly of no great moment at present, may assume a serious phase in the future.

The rainfall of New England is above the average of the whole country in amount, and the distribution throughout the year is quite uniform. The amount of rain that falls and its distribution throughout the year are, in a great measure, the result of geographic position with respect to the great storm paths of the North American continent. Storms that pass over the Great Lakes and up the St. Lawrence Valley bring warmer weather and rain over New England, but the heaviest rains come with atmospheric disturbances which originate in Texas or the South Atlantic Coast. Should the center of the storm pass over or slightly to the south of New England, heavy snow and strong westerly winds generally prevail throughout the northern and western quadrants of the storm area.

The average annual fall varies from about 46 inches in southern Connecticut to less than 33 inches at Burlington, Vt.

Previously published statistics have given an annual average of 50 inches and over at several places in Connecticut and Massachusetts. In a majority of such cases the period of observation was far too short to afford a reliable mean.

The fall of rain and snow over New England is rather uniform, notwithstanding the diversity of surface relief. Beginning on the shore of Long Island Sound, where the fall is greatest, the diminution northward to Strafford, Vt., a distance of about 170 miles, is but 0.03 inch per mile; thence northwestward to Burlington, crossing the Green Mountains, the decrease is much more rapid, being 0.12 inch per mile. The fall west of the Green and Hoosac mountains is generally from 2 to 6 inches per annum less than at points in the Connecticut Valley in the same latitude.

In the upper Connecticut Valley the fall averages about 40 inches, the increased snowfall of winter compensating for the deficit in summer rains as compared with the coastal region. The rainfall of the White Mountain region is somewhat greater than that of less elevated adjacent territory. The rainfall of Maine decreases from the coast inland, though in what proportion it is not possible to state with accuracy. The most northerly point in that State at which continuous observations of rainfall have been made is Hancock Barracks, near the present town of Houlton, Aroostook County. The average fall at this point for the period 1837–1844 was 37.9 inches, a decrease from the coast of about 7 inches, or 0.06 inch per mile.

The coast line in the vicinity of Eastport has an annual fall of about 45 inches. Unfortunately a change in the position of the Eastport gauge has seriously vitiated the record at that point.

RAINFALL OF MOUNTAIN SLOPES.

The rainfall statistics of New England are, with very few exceptions, those of the valley rather than the mountain slope. The precipitation on the mountains is greater on the average than in the adjacent valleys, although, at times, especially in the colder season, the fall of rain or

snow may be greater in the valley than on the mountain sides. The rainfall on the summit of Mount Washington for the months of June, July, August, and September aggregates 39.7 inches, a tenth of an inch greater than the annual fall at the nearest base station, Lunenburg, Vt. The yearly fall on Mount Washington is 83.5 inches (seventeen years' observations). There is, however, some uncertainty attached to these figures owing to the well-known difficulties experienced in measuring precipitation on mountain tops.

The rainfall on Mount Killington, Vermont, 4,300 feet, was measured during July and August of 1889, 1890, and 1891. The averages of the three years for the months above named were 5.27 and 5.47 inches, respectively. This would give an annual fall of 54.7 inches, assuming that the relation between the fall of July and August on Mount Killington is the same as exists at adjacent low level stations.

The average number of rainy days for one or more stations in each of the foregoing named geographic districts is given in the table below.

TABLE VII.—Average number of rainy days.

[0.01 inch or over.]

Stations.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.	Average amount per day.
WASHINGTON.														
Olympia.....	19.3	17.4	17.5	15.9	11.9	10.2	4.8	4.5	9.1	15.6	16.8	21.1	163.8	0.33
Walla Walla.....	14.2	10.9	11.7	10.1	8.7	8.3	8.1	2.2	5.8	9.8	8.8	14.5	107.7	0.14
OREGON.														
Portland.....	19.5	16.4	17.4	14.8	12.5	11.0	4.1	3.5	8.5	13.7	16.4	19.6	156.3	0.30
CALIFORNIA.														
<i>Coast.</i>														
San Francisco.....	11.4	10.6	10.3	7.4	4.2	2.0	0.6	0.8	1.6	3.8	6.4	11.2	69.4	0.24
San Diego.....	5.9	7.0	6.9	4.5	3.2	1.1	0.3	0.7	0.8	2.2	3.0	6.0	42.0	0.23
<i>Great Valley.</i>														
Sacramento.....	9.1	8.3	9.4	6.5	3.8	1.2	0.1	0.0	1.5	3.3	5.0	10.4	64.7	0.31
IDAHO.														
Boise City.....	11.4	10.0	9.1	7.4	7.5	6.2	2.0	1.6	2.6	7.8	6.6	12.7	87.3	0.16
UTAH.														
Salt Lake City.....	10.9	9.5	9.8	9.7	7.3	4.4	3.3	5.1	3.9	6.6	7.0	10.8	87.6	0.21
NEVADA.														
Winnemucca.....	8.7	8.8	8.4	7.4	7.2	4.6	1.9	1.3	2.8	4.2	5.2	10.1	73.4	0.12
ARIZONA.														
Prescott.....	4.5	5.0	5.3	4.5	2.4	1.3	9.5	11.8	4.5	3.5	3.0	5.9	62.2	0.27
NEW MEXICO.														
Santa Fe.....	5.9	6.8	6.1	5.6	6.2	5.9	13.9	12.4	6.7	4.5	4.7	6.2	83.9	0.17
Fort Stanton.....	3.9	4.7	4.9	3.1	4.5	7.0	11.8	11.7	8.3	3.3	4.4	4.5	82.5	0.22
MONTANA.														
Havre.....	9.6	7.7	6.2	6.5	8.4	10.0	7.6	6.0	6.0	6.5	5.8	6.9	87.6	0.16
Helena.....	11.0	8.0	7.7	8.2	10.4	12.5	7.3	4.7	6.5	5.9	6.6	7.9	97.6	0.14
WYOMING.														
Cheyenne.....	5.3	5.4	6.7	9.0	11.5	8.4	9.8	10.0	4.9	5.2	5.0	5.0	85.4	0.15
COLORADO.														
<i>Foothills.</i>														
Denver.....	5.0	5.5	7.0	8.6	11.1	7.5	9.6	9.5	5.2	4.8	4.9	5.2	84.0	0.17
THE PLAINS AND MISSISSIPPI VALLEY.														
<i>North Dakota.</i>														
Bismarck.....	8.1	8.3	8.2	9.1	10.7	12.4	10.5	7.9	6.0	6.7	7.5	8.4	103.9	0.18
<i>Northern Minnesota.</i>														
St. Vincent.....	8.5	8.1	6.9	8.1	7.7	10.7	10.2	8.1	8.2	8.0	7.8	7.4	99.3	0.20

RAINFALL OF THE UNITED STATES.

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TABLE VII.—Average number of rainy days—Continued.

Stations.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.	Average amount per day.
THE PLAINS AND MISSISSIPPI VALLEY—cont'd.														
<i>Southern Minnesota and Southern Wisconsin.</i>														
St. Paul	9.4	8.6	9.9	10.0	11.6	12.0	10.0	9.8	9.4	8.4	8.2	10.2	117.2	0.24
La Crosse	11.4	8.9	9.1	10.4	12.1	11.7	10.2	9.0	10.0	9.0	8.5	9.9	120.6	0.25
Milwaukee	12.9	10.3	12.1	11.0	12.1	11.6	10.0	8.6	9.6	9.8	10.5	12.5	131.4	0.24
<i>Nebraska.</i>														
North Platte	5.1	4.8	6.1	8.6	10.4	10.2	9.6	8.3	4.7	5.0	3.6	5.0	81.2	0.22
Omaha	6.9	6.8	7.9	10.4	11.8	11.1	9.8	8.4	7.8	6.5	4.5	7.1	98.9	0.32
<i>Iowa.</i>														
Davenport	10.1	8.8	9.8	9.9	12.1	12.5	8.4	8.6	9.0	8.3	8.5	10.2	116.9	0.28
<i>Illinois.</i>														
Chicago	11.8	10.8	12.0	11.4	11.8	11.4	9.2	9.0	9.0	10.1	11.0	12.1	131.1	0.26
<i>Kansas.</i>														
Dodge City	4.6	5.8	5.3	6.4	10.4	9.0	8.7	7.2	4.2	5.1	3.4	4.3	75.2	0.26
<i>Missouri.</i>														
St. Louis	9.1	9.5	10.8	10.3	11.8	11.4	9.6	7.6	7.0	7.3	9.1	9.9	112.3	0.36
<i>Oklahoma.</i>														
Fort Sill	6.2	5.7	5.9	6.7	9.8	8.6	6.2	7.3	7.1	5.7	5.5	5.6	85.5	0.35
GULF STATES AND TEXAS.														
Shreveport	11.6	10.1	10.4	9.8	8.6	9.8	9.5	7.3	7.1	6.1	8.9	9.8	109.0	0.44
Montgomery	12.0	11.0	11.0	8.8	9.9	12.1	11.8	11.9	7.7	5.8	8.2	10.8	120.9	0.43
Galveston	11.2	10.1	9.1	6.7	6.6	8.2	9.2	10.2	10.0	6.8	9.0	10.5	107.8	0.44
El Paso	8.4	8.3	2.7	1.0	2.1	8.0	7.9	8.5	5.9	3.8	3.2	8.3	48.3	0.18
San Antonio	9.7	8.4	7.5	7.5	7.5	6.9	5.3	7.2	8.1	6.1	7.2	7.3	89.3	0.34
LOWER MISSISSIPPI VALLEY.														
Nashville	12.9	11.3	12.1	11.1	10.8	11.8	11.0	9.1	8.0	6.9	9.9	11.3	127.5	0.39
Memphis	11.8	11.5	12.2	10.6	10.4	10.4	10.4	8.3	7.5	6.7	10.1	10.8	120.4	0.44
Vicksburg	12.2	11.0	10.5	9.2	8.5	10.3	11.2	9.8	7.2	6.0	9.4	10.3	115.8	0.45
SOUTHERN ATLANTIC STATES AND FLORIDA.														
Charleston	10.6	10.1	10.0	7.7	9.1	10.9	12.1	13.3	10.6	7.4	7.7	8.9	118.5	0.41
Atlanta	13.6	11.6	11.7	9.9	10.0	11.2	11.6	14.0	8.5	6.9	9.2	10.7	123.7	0.39
Jacksonville	9.5	9.1	8.2	6.7	9.8	13.5	15.0	15.0	14.1	9.0	8.0	7.2	124.9	0.43
Key West	8.1	6.8	4.9	4.5	8.5	11.8	12.6	14.6	15.4	12.4	8.0	7.2	117.7	0.33
Tampa	8.4	7.4	7.2	6.0	8.3	17.5	18.0	19.3	19.3	9.0	6.3	6.8	131.8	0.40
APPALACHIAN REGION AND TENNESSEE.														
Knoxville	14.0	12.0	12.7	11.6	12.4	12.6	12.1	11.9	7.8	8.0	9.4	12.1	136.4	0.37
LAKE REGION.														
Duluth	11.1	10.4	9.7	10.3	12.5	14.4	12.0	12.2	12.2	10.2	11.0	11.6	137.0	0.22
Marquette	16.7	13.4	13.5	11.1	11.8	11.9	11.8	11.8	12.7	14.4	15.4	15.8	160.9	0.20
Sault Ste. Marie	19.6	14.7	14.1	11.7	14.8	11.1	12.4	12.7	13.9	14.4	18.9	19.6	177.4	0.17
Grand Haven	19.8	14.1	13.2	11.0	12.1	9.7	8.2	8.7	10.4	11.6	14.6	16.6	150.7	0.22
Detroit	13.7	13.1	13.1	10.4	12.8	11.0	9.3	9.4	9.4	10.4	12.7	15.1	141.5	0.23
Cleveland	16.7	14.1	14.9	12.5	13.5	12.2	10.8	9.6	11.1	12.8	14.8	16.6	155.6	0.24
OHIO VALLEY.														
Pittsburg	16.3	14.5	15.2	13.0	13.2	12.0	13.0	9.1	9.8	10.4	13.1	15.0	156.2	0.23
Cincinnati	14.1	11.9	12.8	12.4	12.2	11.9	10.0	10.0	8.7	9.2	11.2	12.5	137.7	0.31
Indianapolis	12.9	11.5	13.4	12.6	13.2	12.6	10.0	9.8	8.3	9.6	11.8	13.2	139.5	0.30
Louisville	13.0	11.8	12.5	11.9	11.4	11.7	10.0	8.7	7.8	8.3	10.6	11.6	129.7	0.36
Cairo	12.3	10.3	11.3	10.5	11.2	11.8	9.0	8.0	7.0	7.6	9.8	10.9	119.9	0.36
MIDDLE STATES.														
Albany	14.0	12.3	13.7	11.5	12.8	12.5	12.6	10.8	10.1	10.6	12.4	13.0	146.2	0.27
Philadelphia	12.2	11.1	12.5	11.0	11.5	9.4	11.2	10.6	9.2	9.2	10.2	10.1	128.4	0.33
Washington	12.1	10.9	12.2	11.2	12.2	10.5	11.1	11.3	8.6	8.8	10.1	10.4	129.2	0.33
Lynchburg	11.8	10.7	11.2	11.2	12.6	12.2	11.4	11.9	8.8	7.5	9.0	9.6	128.2	0.34
NEW ENGLAND.														
Boston	12.8	11.1	12.8	11.4	11.2	10.3	11.0	10.4	9.6	10.0	11.1	11.7	133.0	0.34

EXCESSIVE PRECIPITATION.

Vast sums of money are expended each year in the construction of sewers and drainage systems. In designing main sewers for large areas a thorough knowledge of the vicissitudes of rainfall of the region, particularly as regards the intensity and duration of the heavier falls, is essential.

A number of quite heavy rainstorms occurred during the past year; in many cases the capacity of the sewers was not equal to the task of discharging the accumulated storm waters. Failure of sewers to carry off flood waters is not a new problem in municipal engineering, although it has cost, in damage to property and resulting litigation, many thousands of dollars.

Attention was first directed to the importance of statistics of excessive rainfall in 1888. At that time automatically recording gauges were in use at but a single station of the Signal Service (now Weather Bureau). At the remaining stations it was not possible to determine the rate of fall except by observing the time of beginning and ending of rain and assuming that the rate was uniform during the continuance of the storm—an assumption known to be far from the truth.

In 1888 rains of 2.50 inches or more in twenty-four consecutive hours and of 1 inch or more in an hour were classed as "excessive," and have since been regularly published in the Monthly Weather Review under that title. From the nature of the observations it was rarely known, in the case of rains of an inch or more in an hour, whether the rain was continuous during the entire hour or whether the bulk of it fell during a fraction of the time; and thus, while the publication of the data did not wholly fail of results, it fell far short of the requirements of the case.

Self-registering rain gauges were sent to five stations in the spring of 1889, and the publication in the Monthly Weather Review of a table of maximum rainfalls in five and ten minutes and one hour was immediately begun.

Excessive rains naturally fall into two broad classes: (*a*) Rains of great intensity and short duration, and (*b*) light intensity and long duration. Of these two classes, those of the first are by far the most damaging and destructive. In extreme cases 95 per cent of the downpour may quickly find its way into the natural or artificial drainage channels. A rainfall of one-half inch in linear depth represents about 11,300 imperial gallons per acre. Assuming that in extreme cases only 5 per cent is absorbed, it is easily seen how great a quantity of water must flow into the drainage basin.

GEOGRAPHICAL DISTRIBUTION OF EXCESSIVE RAINS.

On the Pacific Coast, particularly the coasts of Washington and Oregon, where the annual rainfall is greater than in any other portion of the United States, excessive rains of class *a* are not prevalent. The rain of this region falls principally between September and May, the colder part of the year, when convectional overturning of the atmosphere is least active.

The most favorable conditions for the sudden condensation of a vast quantity of water vapor are conceived to be (1) strong vertical temperature gradients; (2) high surface temperatures and humidity—in fact, the general conditions of humidity and instability of the atmosphere necessary to the formation of thunderstorms and tornadoes.

The most violent rains of class *a*, and, at the same time, those of which least is known, are the so-called cloud-bursts of the mountainous and arid regions of the West. These storms are not confined to any particular State or region, but may occur in mountainous localities throughout the entire territory bounded by the British possessions on the north, the Mexican border on the south, the foothills of the Rockies on the east, and the Sierras on the west. In the true cloud-burst the rain seems to pour down, rather than fall in drops. It often happens that the downpour occurs over narrow basins or on mountain slopes whose outlets are canyons or gorges leading to a valley or plain below. In such cases almost the entire amount of water quickly finds its way into the drainage channel, and as a result, a wave of water rushes down the outlet with great velocity and in sufficient volume to destroy everything in its path. Such a flood wave almost swept away the town of Eureka, Nev., in 1874, and caused the loss of fifteen lives. A far greater disaster occurred in Bear Creek canyon, Colorado, in July, 1896, when thirty lives were lost and property valued at more than \$100,000 was destroyed.

The amount of rain that falls in one of these torrential downpours has never been ascertained. A cloud-burst passed over the edge of the little town of Palmetto, Nev., in August, 1890. A rain gauge that was not exposed to the full intensity of the storm caught 8.80 inches of water in an hour. In August, 1891, two storms passed over Campo, Cal., within a few minutes of each other. The second storm was a veritable cloud-burst. The observer succeeded in measuring the rainfall of the first shower and a portion of the second. Eleven and a half inches were measured within an hour. The rain gauge and support were carried away by the torrent of water, and the full record of the storm was not obtained.

The great majority of excessive rains (class *a*) in the United States occur east of the one hundred and fifth meridian, and principally in the summer months. They are most frequent in connection with summer afternoon thunderstorms, but occasionally occur in the track of West India hurricanes. They are more abundant on the Gulf and South Atlantic coasts than at inland points.

In Table VIII there are given the essential facts concerning each excessive rain, of which permanent record was made at Washington, D. C., 1881-1896; Savannah, Ga., 1889-1896, and St. Louis, Mo., 1889-1896. Columns 1 and 2 give the total duration of the storm; column 3 the total depth of rainfall; columns 4 and 5 the beginning and ending, respectively, of the excessive rate; column 6 the amount of rain that fell before the excessive rate began. In the succeeding columns the accumulated amounts of rainfall are given for each successive five minutes of the storm's duration up to fifty minutes, and in ten and twenty minute periods thereafter.

It is possible to determine, from the details thus presented, whether or not rain falls at a uniform rate and how long such rate continues, and also the approximate time when the flow in the sewers shall be at a maximum for any given rate.

MAXIMUM INTENSITY OF RAINFALL.

It is generally assumed that in heavy showers the intensity (*i*) varies inversely as the duration (*t*), and a number of formulæ have been suggested to express the relation between (*i*) and (*t*). From an examination of the data in Table I it would seem to be extremely doubtful whether a relation sufficiently definite to admit of expression by mathematical formulæ exists. The general principle that rains of the highest intensity exhaust themselves quickly holds good, but the fact remains that the total duration of the storm bears no simple relation either to the rate or linear depth of rainfall.

The periods of very great intensity are of short duration and may occur at any time during the continuance of the storm. There may be two and even three periods of great intensity in a single storm, separated by intervals of light rain. The table below shows the time of occurrence of the maximum intensity, counting from the beginning of the storm.

Percentage of cases in which the maximum intensity of rainfall occurred within five, ten, and sixty minutes from the beginning of the storm.

	Washing- ton.	Savannah.	St. Louis.
	Per cent.	Per cent.	Per cent.
Maximum intensity occurred within—			
5 minutes from beginning of storm	17	10	32
10 minutes from beginning of storm	21	20	30
15 minutes from beginning of storm	20	21	8
20 minutes from beginning of storm	5	13	5
25 minutes from beginning of storm	8	7	2
30 minutes from beginning of storm	9	10	2
35 minutes from beginning of storm	5	5	2
40 minutes from beginning of storm	5	1	8
45 minutes from beginning of storm	2	4	5
50 minutes from beginning of storm	1	5	5
60 minutes from beginning of storm	6	3	2

If we select from the whole number of individual storms those shorter periods during which a very high rate was maintained, and plot the rates per hour as abscissæ in a system of rectilinear coordinates, we obtain, after connecting the points so plotted, a curve which may be called the curve of probable maximum intensity. Thus we find that at Washington during the last sixteen years the highest rate per hour was as follows:

	Inches.	Date.
For any—		
5 consecutive minutes	7.50	Sept. 3, 1882
10 consecutive minutes	5.10	Sept. 16, 1888
15 consecutive minutes	4.50	June 27, 1881
20 consecutive minutes	3.90	Do.
25 consecutive minutes	3.60	Do.
30 consecutive minutes	3.15	Do.
40 consecutive minutes	2.75	June 10, 1876
50 consecutive minutes	2.30	Do.
60 consecutive minutes	1.98	Do.
120 consecutive minutes	1.23	July 26, 1886

Plate III shows the curves of probable maximum intensity for Washington (*a*) and Savannah (*b*) constructed in the manner indicated. The full-line curve on Plate III, constructed from the combined records of excessive rainfall in the cities of Boston, Providence, New York, Philadelphia, and Washington, representing observations for an aggregate of about seventy years, has been reproduced from Ex. Doc. No. 445, Fifty-first Congress, first session—Report upon the Sewerage of the District of Columbia, Washington, D. C., 1890.

The conclusion to be drawn from the similarity of the curves is that, in general, the highest intensity of any individual storm will not greatly exceed the limits marked by the separate curves.

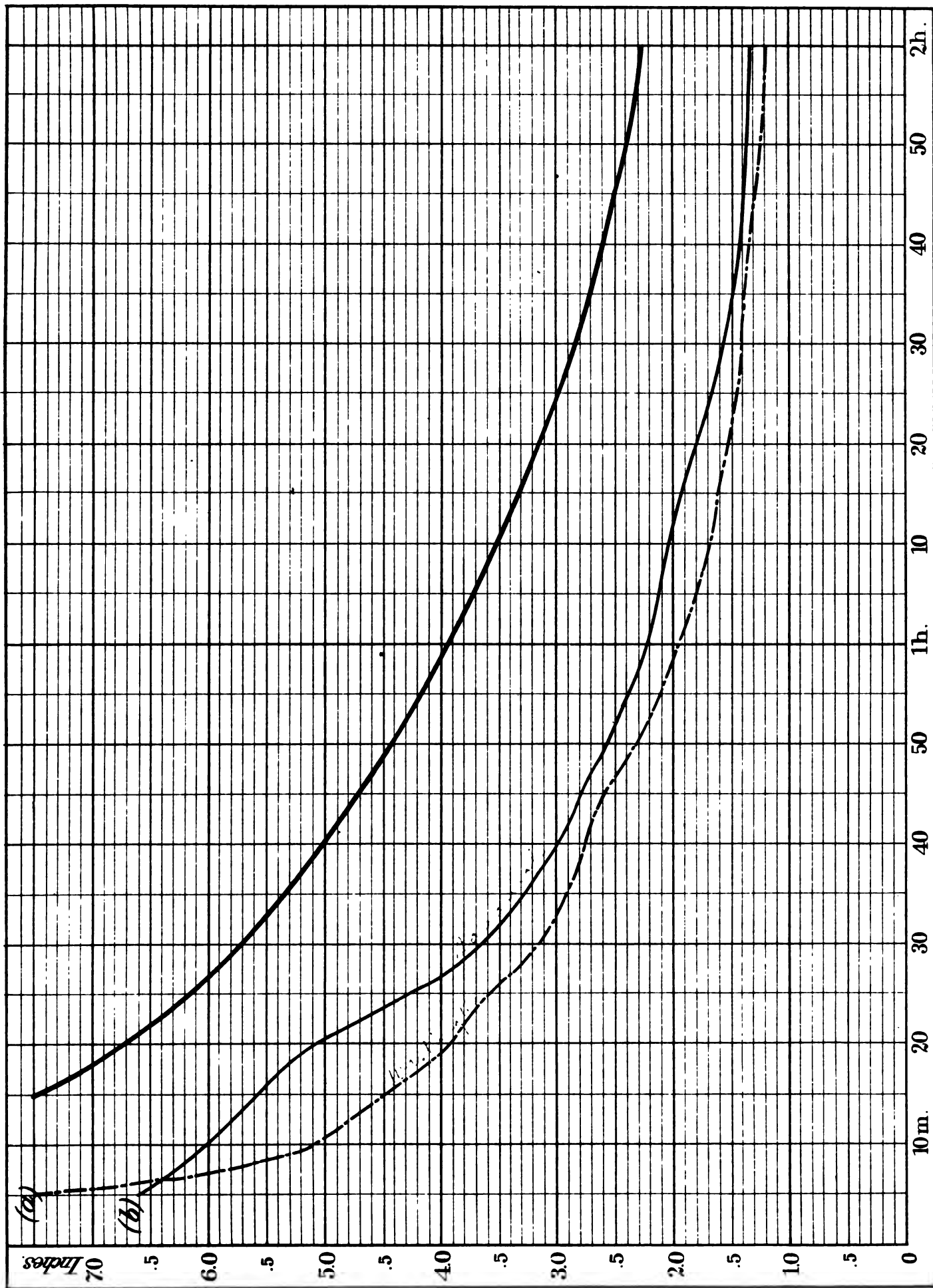
TABLE VIII.—Details of excessive rainfall, Washington, Savannah, and St. Louis.

Station and date.	Total duration.		Total amount of precipitation (inches).	Excessive rate.		Amount before excessive rate began (inches).	Depths of precipitation (in inches) during periods of time as indicated.													
	From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
WASHINGTON, D. C.																				
1881.																				
June 27.....	1.25 p.m.			1.30 p.m.	1.40 p.m.	0.03	0.01	0.10	0.23	0.24	0.25									
27.....		3.45 p.m.	0.72	3.25 p.m.	3.35 p.m.	.07	.05	.30	.46	.46	.47									
27.....	8.10 p.m.	8.45 p.m.	1.63	8.10 p.m.	8.40 p.m.	.00	.21	.51	1.02	1.31	1.50	1.57	1.61							
Sept. 11.....	4.30 p.m.	8.30 p.m.	1.05	4.35 p.m.	5.00 p.m.	.01	.01	.10	.35	.51	.70	.84	.88	0.89						
1882.																				
Mar. 27-28.....	9.35 p.m.	7.25 a.m.	.61	9.40 p.m.	9.45 p.m.	.01	.01	.43	.44											
May 27.....	8.05 p.m.	10.45 p.m.	.88	8.10 p.m.	8.25 p.m.	.01	.06	.45	.70	.81	.82									
July 4.....	9.30 a.m.	1.45 p.m.	1.82	11.20 a.m.	11.30 a.m.	.40	.02	.05	.07	.10	.19	.28	.34	.37	0.44	0.49	0.56			
Sept. 3.....	8.15 p.m.	About midnight.	1.36	8.20 p.m.	12.45 p.m.	.28	.01	.02	.05	.09	.23	.40	.53	.65	.71	.80	.87	0.91	0.94	0.96
20.....	9.35 p.m.	1.21 a.m.	1.16	9.35 p.m.	10.00 p.m.	.04	.04	.14	.75	.85	1.10	1.15	1.17	1.18	1.19	1.19	1.20	1.25	1.32	1.34
1883.																				
May 14.....	9.20 p.m.	10.00 p.m.	.47	9.20 p.m.	9.25 p.m.	.00	.39	.45												
June 3.....	12.50 p.m.			2.20 p.m.	2.40 p.m.	.05	.04	.15	.25	.44	.51	.54	.55	.56						
3.....		4.45 p.m.	1.15	4.10 p.m.	4.20 p.m.	.08	.01	.04	.05	.06	.08	.40	.55	.57	.59					
10.....	8.25 p.m.	11.00 p.m.	1.24	8.30 p.m.	9.00 p.m.	.04	.04	.31	.37	.43	.52	.74	.80	.81	.82	.83	.85	.95	1.15	1.20
13.....	5.10 p.m.	7.00 p.m.	.75	5.15 p.m.	5.25 p.m.	.01	.01	.10	.61	.68	.72	.74								
21.....	8.10 p.m.	9.00 p.m.	.65	8.15 p.m.	8.30 p.m.	.02	.02	.20	.40	.55	.60	.64								
July 12.....	2.35 p.m.	10.00 p.m.	.59	2.40 p.m.	3.05 p.m.	.10	.01	.06	.20	.25	.35	.45	.52	.54	.56					
17.....	1.00 p.m.	4.00 p.m.	.83	1.00 p.m.	1.20 p.m.	.00	.23	.37	.60	.78	.80	.81								
24.....	4.40 p.m.	6.00 p.m.	.77	4.40 p.m.	5.05 p.m.	.01	.01	.15	.21	.39	.64	.70	.74	.75						
Aug. 23.....	4.10 p.m.	5.00 p.m.	.97	4.10 p.m.	4.35 p.m.	.00	.20	.40	.64	.80	.90	.93	.95							
1884.																				
Jan. 8.....	3.00 a.m.	10.00 p.m.	1.83	5.05 p.m.	5.08 p.m.	.01	.01	.07	.48	.50	.51	.54	.55	.56	.57	.60	.65	.69	.80	.88
June 10-11.....	10.00 p.m.	3.15 a.m.	1.69	Midnight.	12.25 a.m.	.96	.02	.03	.07	.16	.19	.24	.27	.32	.36	.39	.43	.59	.70	.94
13.....	12.35 p.m.	5.15 p.m.	1.60	12.40 p.m.	1.15 p.m.	.02	.02	.16	.21	.41	.50	.63	.76	.96	.97	1.03	1.10	1.13	1.25	1.42
July 1.....	4.30 p.m.	9.15 p.m.	2.03	6.45 p.m.	7.00 p.m.	.04	.01	.32	.58	.63	.63	.63	.63	.66	.68	.68	.88	1.52	1.64	1.97
11.....	2.05 p.m.	3.00 p.m.	.64	2.15 p.m.	2.35 p.m.	.02	.08	.28	.48	.58	.60	.61	.62	.63						
Nov. 23.....	4.35 p.m.	10.10 p.m.	1.27	6.55 p.m.	7.50 p.m.	.16	.09	.12	.15	.24	.35	.44	.53	.65	.75	.89	.96	.98	.99	1.06

a About.

Curves of Probable Maximum Intensity of Rainfall.

Plate III.



RAINFALL OF THE UNITED STATES.

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TABLE VIII.—Details of excessive rainfall, Washington, Savannah, and St. Louis—Continued.

Station and date.	Total duration.		Total amount of precipitation (inches).	Excessive rate.		Amount before excessive rate began (inches).	Depths of precipitation (in inches) during periods of time as indicated.													
	From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
WASHINGTON, D.C.—cont'd.																				
1885.																				
May 27.....	Noon.	10.05 p.m.	1.09	12.30 p.m.	12.40 p.m.	0.16	0.02	0.04	0.08	0.10	0.13	0.15	0.25	0.33	0.35	0.42	0.50	0.60	0.64	0.68
June 28.....	7.45 a.m.	10.40 a.m.	.78	8.55 a.m.	9.10 a.m.	.19	.05	.17	.30	.42	.48	.52	.53	.57						
Aug. 2.....	5.35 p.m.	6.20 p.m.	.62	5.40 p.m.	6.00 p.m.	.02	.02	.20	.39	.56	.60	.61	.62							
2.....	8.20 p.m.	9.30 p.m.	.34	8.30 p.m.	8.35 p.m.	.05	.01	.03	.18	.21	.23	.26	.27	.27	.29	.31	.33	.34		
23.....	1.35 p.m.	2.15 p.m.	.69	1.35 p.m.	2.00 p.m.	.00	.10	.26	.44	.60	.66	.67	.68							
25.....	5.25 p.m.	9.15 p.m.	.94	5.25 p.m.	5.40 p.m.	.00	.10	.45	.55	.58	.59	.60	.60	.71	.74	.75	.85	.90	.91	.94
Oct. 29.....	11.00 a.m.	1.00 a.m.	2.52	8.25 p.m.	8.45 p.m.	.46	.01	.01	.05	.07	.09	.10	.30	.45	.60	.69	.80	1.05	1.27	1.45
1886.																				
Mar. 31.....	11.00 a.m.	7.15 p.m.	1.48	1.00 p.m.	1.15 p.m.	.22	.10	.28	.37	.44	.51	.55	.57	.60	.61	.62	.65	.68	.70	.72
May 22-23.....	11.30 p.m.	1.30 a.m.	.85	11.40 p.m.	12.05 a.m.	.08	.03	.06	.16	.20	.27	.57	.66	.70	.72	.76	.82	.84	.85	
25.....	12.50 a.m.	3.30 a.m.	.80	2.20 a.m.	2.35 a.m.	.27	.01	.02	.03	.04	.17	.33	.36	.44	.47	.48	.54	.56		
June 22-23.....	5.45 a.m.	1.05 a.m.	8.47	7.30 p.m.	8.00 p.m.	2.49	.03	.07	.08	.09	.10	.11	.30	.38	.42	.50	.65	.77	.82	.85
24.....	1.25 p.m.	4.00 p.m.	1.45	2.25 p.m.	3.25 p.m.	.30	.03	.05	.08	.12	.16	.20	.37	.46	.56	.69	.96	1.10	1.34	
July 13.....	8.35 a.m.	12.30 p.m.	.88	11.00 a.m.	11.15 a.m.	.24	.03	.12	.25	.26	.28	.34	.38	.43	.47	.49	.53			
15-16.....	7.10 p.m.	12.10 a.m.	1.65	7.20 p.m.	7.35 p.m.	.06	.04	.11	.40	.60	.78	.82	.85	.85	.85	.85	.90	1.20	1.38	1.46
21.....	1.45 a.m.	4.00 a.m.	.22	4.00 a.m.	4.15 a.m.	.22	.01	.01	.10	.30	.42	.51	.55	.58						
21.....	6.45 a.m.	6.45 a.m.	1.27	6.25 a.m.	6.40 a.m.	.20	.19	.37	.44	.45										
26.....	6.30 p.m.	9.45 p.m.	2.80	7.20 p.m.	8.50 p.m.	.07	.03	.13	.15	.37	.67	.93	1.03	1.10	1.14	1.18	1.53	1.93	2.30	2.47
Aug. 1.....	12.45 p.m.	2.30 p.m.	.73	1.15 p.m.	1.30 p.m.	.25	.05	.08	.13	.20	.24	.30	.50	.60	.67	.69				
30.....	6.40 p.m.	9.00 p.m.	.98	7.35 p.m.	7.50 p.m.	.00	.10	.20	.28	.30										
				8.20 p.m.	8.35 p.m.	T.	.10	.21	.33	.35										
						T.	.01	.12	.16	.25	.32									
1887.																				
July 4-5.....	11.00 p.m.	8.00 a.m.	.96	4.15 a.m.	4.20 a.m.	.35	.01	.16	.21	.25	.26	.29	.32	.35	.40	.45	.48			
Aug. 11.....	6.35 p.m.	7.15 p.m.	.82	6.35 p.m.	7.00 p.m.	.00	.17	.40	.52	.72	.77	.78	.80	.81						
Sept. 12.....	11.10 p.m.	11.30 p.m.	.67	11.10 p.m.	11.20 p.m.	.00	.30	.62	.66											
1888.																				
June 14.....	4.52 p.m.	5.15 p.m.	.40	4.52 p.m.	5.05 p.m.	.00	.15	.32	.39	.40										
23.....	3.30 p.m.	7.00 p.m.	.70	3.30 p.m.	3.45 p.m.	.00	.20	.35	.55	.59	.64	.66	.67	.68						
July 9.....	8.45 p.m.	10.30 p.m.	1.17	9.35 p.m.	10.00 p.m.	.10	.03	.06	.07	.08	.33	.68	.78	.98	1.11	1.12	1.14			
July 10.....	1.25 a.m.	Noon.	1.67	2.05 a.m.	2.20 a.m.	.09	.02	.03	.05	.05	.06	.07	.08	.09	.23	.33	.45	.58	.61	.62
Aug. 21.....	1.30 p.m.	3.55 p.m.	.76	1.30 p.m.	1.45 p.m.	.00	.30	.40	.60	.62	.63									
Sept. 16.....	8.00 p.m.	6.30 p.m.	1.45	3.00 p.m.	3.20 p.m.	.00	.15	.55	1.00	1.15	1.23	1.24	1.24	1.25	1.26	1.26	1.28	1.81	1.84	1.89
1889.																				
May 19-20.....	7.30 a.m.	7.00 a.m.	1.37	5.05 p.m.	5.22 p.m.	.10	.02	.05	.19	.28	.40	.46	.48	.50						
20.....	11.45 a.m.	6.15 p.m.	1.15	12.23 p.m.	12.50 p.m.	.10	.05	.25	.33	.40	.50	.60	.68	.73	.75	.76	.78	.84	.90	
31.....	D. N. b	D. N.	1.85	2.30 p.m.	2.35 p.m.	(f)	.20	.26	.32	.34	.35	.35	.35	.35	.36	.37	.39	.42	.51	.77
June 10.....	1.15 p.m.	1.40 p.m.	.35	1.18 p.m.	1.28 p.m.	T.	.10	.28	.35											
July 1.....	10.45 a.m.	7.00 p.m.	1.47	11.48 a.m.	12.05 p.m.	.45	.10	.20	.21	.22	.23	.25	.45	.69	.85	.98	1.02	1.06	1.11	1.17
15.....	6.25 a.m.	7.00 a.m.	.50	6.50 a.m.	6.58 a.m.	.05	.25	.41	.42	.43	.44	.45								
30-31.....	8.30 p.m.	11.45 a.m.	1.85	9.03 p.m.	9.33 p.m.	.20	.06	.10	.22	.30	.36	.42	.35	.70	.75	.75	.77	.80	.82	.85
Aug. 6.....	7.15 p.m.	11.00 p.m.	1.06	9.50 p.m.	10.08 p.m.	.15	.05	.10	.15	.25	.55	.85	.93	.97	1.00	1.02	1.05			
9.....	4.40 p.m.	5.45 p.m.	.60	4.58 p.m.	5.18 p.m.	.05	.10	.35	.48	.55										
1890.																				
May 20.....	6.55 a.m.	9.20 a.m.	.60	6.55 a.m.	7.06 a.m.	.00	.25	.43	.48	.50	.51	.52	.53	.54	.55	.55	.57	.60		
June 12.....	6.08 p.m.	8.17 p.m.	.52	6.08 p.m.	6.19 p.m.	.00	.20	.35	.38	.40	.41	.42	.43	.44	.45					
22.....	9.18 p.m.	9.50 p.m.	.52	9.23 p.m.	9.43 p.m.	.05	.05	.25	.50	.50	.51	.52								
July 2.....	6.30 p.m.	8.35 p.m.	.68	7.24 p.m.	7.36 p.m.	.05	.30	.57	.64	.67	.70	.72	.74	.75	.77	.79				
Aug. 1.....	4.48 p.m.	7.20 p.m.	1.35	5.50 p.m.	6.07 p.m.	.05	.05	.07	.08	.10	.15	.22	.35	.50	.56	.58	.65			
14.....	6.40 p.m.	11.20 p.m.	1.00	10.43 p.m.	10.58 p.m.	.10	.10	.20	.25	.27	.35	.55	.63	.65						
20.....	9.12 p.m.	D. N.	.82	9.12 p.m.	9.25 p.m.	.00	.25	.55	.60	.65										
Sept. 11.....	5.12 p.m.	7.05 p.m.	.90	5.25 p.m.	6.15 p.m.	.20	.17	.22	.30	.32	.33	.34	.35	.65	.80	.90				
1891.																				
June 18.....	4.50 p.m.	10.30 p.m.	1.20	5.32 p.m.	6.00 p.m.	.05	.07	.25	.40	.52	.62	.70	.75	.80	.85					
21.....	5.10 p.m.	7.40 p.m.	.95	5.22 p.m.	5.28 p.m.	.05	.05	.14	.22	.26	.31	.33	.34	.35	.43	.60	.95			
July 15.....	1.53 p.m.	2.20 p.m.	.65	2.07 p.m.	2.20 p.m.	.05	.01	.03	.10	.35	.65									
23.....	5.34 p.m.	6.05 p.m.	.40	5.34 p.m.	5.47 p.m.	.00	.20	.35	.40											
Aug. 24.....	9.43 p.m.	D. N.	.80	9.43 p.m.	10.08 p.m.	.00	.15	.22	.27	.35	.55	.61	.63	.65						
Sept. 5.....	7.03 p.m.	8.45 p.m.	.75	7.03 p.m.	7.08 p.m.	.00	.25	.29	.31	.33	.35	.47	.56	.66	.68	.69	.71	.75		
Oct. 19.....	9.25 a.m.	11.40 a.m.	.86	11.03 a.m.	11.25 a.m.	.05	.25	.02	.05	.08	.13	.20	.35	.60	.70					

a Another short period of excessive rainfall occurred between 8.10 p.m. and 8.20 p.m., when 0.28 inch fell.

b Rain occurred between 9 p.m. and 8 a.m. June 1; beginning and ending not known; amount between 8 p.m. 31st and 8 a.m. June 1, 3.11 inches, instrument not recording properly, and gauge overflowed at 7.25 p.m.

c By stick, 2.31 inches. Gauge overflowed at 4 a.m. 31st.

TABLE VIII.—Details of excessive rainfall, Washington, Savannah, and St. Louis—Continued.

Station and date.	Total duration.		Total amount of precipitation (inches).	Excessive rate.		Amount before excessive rate began (inches).	Depths of precipitation (in inches) during periods of time as indicated.														
	From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.	
WASHINGTON, D. C.—cont'd.																					
1892.																					
June 23.....	3.32 p.m.	4.08 p.m.	0.36	3.50 p.m.	4.03 p.m.	0.05	0.01	0.02	0.03	0.08	0.13	0.34	0.36								
27.....	4.40 p.m.	D. N.	.86	5.03 p.m.	5.11 p.m.	.05	.18	.36	.38	.39	.42	.45	.48	.50	.54	.57	.70				
July 14.....	6.10 a.m.	7.35 a.m.	.74	6.15 a.m.	6.20 a.m.	.05	.05	.14	.18	.21	.23	.25	.32	.50	.58	.61	.70				
19.....	5.05 p.m.	7.40 p.m.	.94	6.37 p.m.	7.00 p.m.	.20	.08	.08	.14	.24	.46	.64	.71	.75	.78	.83	.86				
27.....	8.20 p.m.	D. N.	.84	8.20 p.m.	8.42 p.m.	.00	.15	.40	.53	.63	.66										
1893.																					
June 26.....	3.30 a.m.	4.30 a.m.	.52	3.30 a.m.	3.43 a.m.	.00	.15	.32	.37	.39	.41	.43	.45	.48	.50						
Sept. 15.....	5.15 p.m.	6.00 p.m.	.45	5.42 p.m.	5.53 p.m.	.05	.15	.30	.38	.40											
1894.																					
May 5.....	8.32 p.m.	9.50 p.m.	.46	9.00 p.m.	9.10 p.m.	.09	.01	.02	.07	.09	.21	.40	.44	.46							
6.....	D. N.	D. N.	.62	9.50 p.m.	10.15 p.m.	T.	.10	.20	.37	.44	.48	.51	.52	.53	.54	.55	.57	.59	.61		
18.....	3.25 p.m.	5.32 p.m.	.46	3.35 p.m.	3.50 p.m.	T.	.15	.28	.38	.43	.44										
18.....	8.20 p.m.	D. N.	.46	9.00 p.m.	9.05 p.m.	.14	.06	.11	.12	.12	.12	.12	.18	.15	.27	.29	.31	.34			
Dec. 11-12.....	11.30 p.m.	2.15 p.m.	1.16	10.50 a.m.	11.00 a.m.	.04	.02	.02	.02	.04	.26	.29	.31	.32	.33	.34	.35				
1895.																					
June 13.....	3.13 p.m.	5.30 p.m.	.72	3.25 p.m.	3.47 p.m.	.06	.03	.06	.14	.34	.44	.50	.62	.68	.68	.68	.69	.70	.71	.72	
29.....	7.05 p.m.	9.10 p.m.	.90	7.24 p.m.	7.40 p.m.	T.	.24	.06	.80	.83	.85	.86	.87	.88	.88	.89	.90				
30.....	3.20 p.m.	8.25 p.m.	.86	5.30 p.m.	5.45 p.m.	.22	.07	.28	.36	.37	.37	.45	.54	.56	.58	.60	.63				
30.....	9.20 p.m.	1.15 a.m.	1.47	10.15 p.m.	10.45 p.m.	.14	.08	.12	.13	.13	.14	.34	.54	.64	.99	1.24	1.36	1.41			
Dec. 26.....	8.10 p.m.	9.25 p.m.	.80	8.15 p.m.	8.25 p.m.	T.	.18	.25	.25	.25	.26	.27	.27	.28	.29						
1896.																					
Aug. 13.....	5.20 p.m.	8.24 p.m.	1.73	6.20 p.m.	7.00 p.m.	.05	.14	.33	.75	.95	1.15	1.34	1.45	1.52	1.57						
SAVANNAH, GA.																					
1889.																					
June 27.....	7.55 a.m.	10.15 a.m.	1.35	9.10 a.m.	10.00 a.m.	.05	.10	.17	.48	.81	.87	.98	1.01	1.13	1.21	1.29					
28.....	3.25 a.m.	9.37 a.m.	1.60	6.33 a.m.	7.12 a.m.	.45	.05	.15	.21	.26	.45	.60	.70	.80	.86	.90					
July 6.....	4.15 p.m.	7.00 p.m.	.95	4.20 p.m.	4.46 p.m.	.05	.30	.39	.47	.56	.65	.69	.71	.74	.75						
Aug. 6.....	3.25 p.m.	8.30 p.m.	2.60	4.08 p.m.	4.52 p.m.	.10	.03	.06	.09	.40	.75	1.10	1.48	1.72	1.92	2.03	2.22	2.28	2.40		
8.....	11.55 a.m.	1.20 p.m.	1.20	11.55 a.m.	12.15 p.m.	.00	.40	.80	.95	1.05	1.08										
Sept. 1.....	8.18 a.m.	9.30 a.m.	1.10	8.42 a.m.	9.00 a.m.	.15	.06	.12	.13	.14	.20	.60	.85	1.08	1.10						
6.....	12.20 p.m.	1.30 p.m.	1.10	12.40 p.m.	1.00 p.m.	.15	.07	.11	.25	.55	.80	1.00	1.05								
1890.																					
May 3.....	9.00 a.m.	10.00 a.m.	.60	9.35 a.m.	9.50 a.m.	.05	.18	.30	.55												
June 11.....	3.30 p.m.	4.05 p.m.	.90	3.28 p.m.	3.58 p.m.	.10	.05	.20	.50	.70	.80	.85	.90								
20.....	1.52 p.m.	3.40 p.m.	.75	1.57 p.m.	2.15 p.m.	.05	.05	.22	.34	.45	.62	.66	.68	.70							
July 1.....	2.15 p.m.	2.55 p.m.	.70	2.15 p.m.	2.27 p.m.	.00	.15	.50	.63	.66	.68	.70									
2.....	6.25 a.m.	8.20 a.m.	.60	6.35 a.m.	6.52 a.m.	.10	.05	.09	.20	.30	.45	.51									
8.....	7.10 p.m.	8.20 p.m.	1.10	7.35 p.m.	7.53 p.m.	.10	.15	.50	.85	.96	.98	.99	1.00								
27.....	1.00 p.m.	4.00 p.m.	1.50	1.08 p.m.	1.20 p.m.	.05	.05	.35	.57	.65	.68	.70	.75	.77	.79	.80	.83				
Sept. 1.....	11.40 p.m.	1st.	1.50	2.10 p.m.	2.23 p.m.	.25	.02	.06	.17	.39	.44	.47	.49	.53	.55	.56	.59				
2.....	1st.	2.00 p.m.	4.25	10.25 a.m.	10.57 a.m.	.20	.06	.12	.17	.25	.40	.50	.53	.56	.64	.69	.75	.85	1.06	1.15	
3.....	5.25 p.m.	6.25 p.m.	.45	6.13 p.m.	6.21 p.m.	2.22	.02	.05	.08	.16	.25	.30	.40	.60	.85	.92	.98	1.10	1.27	1.50	
11.....	2.20 p.m.	3.20 p.m.	.55	2.20 p.m.	2.35 p.m.	.20	.03	.07	.10	.12	.15	.20	.40								
13.....	1.00 p.m.	1.30 p.m.	.75	1.00 p.m.	1.25 p.m.	.00	.10	.25	.36	.60	.75										
15.....	7.40 p.m.	11.50 p.m.	1.10	8.28 p.m.	8.45 p.m.	.10	.03	.10	.25	.40	.49	.54	.53	.61	.64	.66	.71	.77	.82	.86	
22.....	12.45 p.m.	1.40 p.m.	.40	12.45 p.m.	12.55 p.m.	.00	.12	.35													
24-25.....	8.40 p.m.	5.10 a.m.	4.56	10.17 p.m.	11.06 p.m.	.20	.10	.13	.18	.25	.45	.65	.80	1.02	1.15	1.17	1.40	1.75			
Oct. 22.....	6.00 a.m.	2.30 p.m.	2.10	10.27 a.m.	10.47 a.m.	.55	.03	.05	.07	.10	.15	.20	.30	.45	.59	.75	.82	.88	.95	1.25	
22.....	9.25 p.m.	11.35 p.m.	1.20	11.03 p.m.	11.25 p.m.	.10	.07	.25	.60	.85	.99	1.00									
Dec. 8.....	6.50 a.m.	8.30 a.m.	1.25	7.02 a.m.	7.28 a.m.	.05	.20	.32	.55	.80	1.00	1.08	1.12	1.16							
1891.																					
May 27.....	12.38 p.m.	10.20 p.m.	1.10	7.48 p.m.	8.02 p.m.	.30	.35	.53	.58	.60	.63	.66	.68	.69	.70						
July 18.....	1.50 p.m.	4.40 p.m.	2.09	1.58 p.m.	2.80 p.m.	.05	.40	.85	1.25	1.50	1.70	1.82	1.85								
25.....	1.00 p.m.	1.30 p.m.	.45	1.07 p.m.	1.15 p.m.	.05	.04	.25	.45												
26.....	3.10 p.m.	5.50 p.m.	1.60	3.10 p.m.	4.07 p.m.	.00	.10	.20	.27	.30	.45	.68	.85	1.02	1.15	1.23	1.47	1.55			
28.....	1.00 p.m.	2.20 p.m.	1.25	1.22 p.m.	2.00 p.m.	.10	.12	.20	.39	.47	.70	.95	1.13	1.15							
Aug. 2.....	1.35 p.m.	2.30 p.m.	.55	1.35 p.m.	1.55 p.m.	.00	.13	.33	.40	.50	.55										
6.....	2.10 p.m.	3.12 p.m.	.60	2.18 p.m.	2.30 p.m.	.05	.03	.10	.35	.50	.54	.56	.60								
13.....	6.20 p.m.	9.25 p.m.	1.41	6.58 p.m.	7.28 p.m.	.05	.10	.18	.22	.26	.41	.73	1.03	1.16	1.23	1.30	1.35				
22.....	8.08 p.m.	D. N.	1.75	8.08 p.m.	8.43 p.m.	.00	.10	.40	.65	.90	1.10	1.18	1.25	1.30	1.33	1.35	1.38				
28.....	11.40 a.m.	4.35 p.m.	3.15	1.40 p.m.	2.10 p.m.	.50	.02	.04	.07	.14	.18	.25	.40	.65	.80	1.40	1.70	1.78			
				2.55 p.m.	3.10 p.m.	.15	.02	.03	.04	.05	.07	.42	.62	.87	.93	.95	.97	1.03	1.11		

a Record begins at 11.40 p.m. 1st.

b Record begins at 10.08 a.m. 2d. 0.25 inch fell between 1.40 and 2.20 a.m., when gauge overflowed. 1.02 inches is estimated to have fallen between 2.20 and 7 a.m.

c Gauge overflowed at 11.06 p.m. 24th.

TABLE VIII.—Details of excessive rainfall, Washington, Savannah, and St. Louis—Continued.

Station and date.	Total duration.		Total amount of precipitation (inches).	Excessive rate.		Amount before excessive rate began (inches).	Depths of precipitation (in inches) during periods of time as indicated.													
	From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
SAVANNAH, GA.— continued.																				
1892.																				
July 18.....	12.10 p.m.	4.50 p.m.	1.83	1.10 p.m.	1.50 p.m.	0.25	0.28	0.50	0.70	0.77	0.80	0.84	1.10	1.30	1.33	1.35	1.40	1.48	1.52	.....
Aug. 10.....	3.11 p.m.	4.45 p.m.	.79	3.18 p.m.	3.35 p.m.	.05	.08	.15	.40	.55	.72	.75	.....	.....	.....	.....	.....	.....	.....	.....
Sept. 11-12.....	7.25 p.m.	10.35 a.m.	2.52	9.42 a.m.	9.57 a.m.	1.92	.05	.07	.10	.12	.15	.18	.25	.40	.65	.78	.....	.....	.....	.....
19.....	4.25 p.m.	5.45 p.m.	.57	4.45 p.m.	5.00 p.m.	.05	.15	.35	.45	.47	.48	.49	.50	.51	.....	.....	.....	.....	.....	.....
20.....	7.05 p.m.	11.00 p.m.	1.77	7.05 p.m.	7.42 p.m.	.05	.07	.15	.25	.40	.55	.70	.82	.89	.95	.97	1.00	1.15	1.32	1.44
1893.																				
June 7.....	4.10 p.m.	4.55 p.m.	.88	4.20 p.m.	4.40 p.m.	.05	.02	.05	.25	.50	.70	.80	.85	.87	.88	.....	.....	.....	.....	.....
July 15.....	3.50 p.m.	7.00 p.m.	1.62	4.00 p.m.	4.22 p.m.	.05	.12	.15	.25	.31	.33	.35	.40	.50	.65	.83	1.19	1.45	.....	.....
Aug. 3.....	12.55 p.m.	5.00 p.m.	.76	4.35 p.m.	5.13 p.m.	.10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
14.....	4.07 p.m.	6.25 p.m.	.72	1.07 p.m.	1.26 p.m.	.05	.10	.35	.55	.67	.70	.....	.....	.....	.....	.....	.....	.....	.....	.....
20.....	5.45 p.m.	7.40 p.m.	.87	5.35 p.m.	5.47 p.m.	.08	.25	.40	.61	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
27.....	10.30 a.m.	6.00 a.m.	5.61	5.53 p.m.	6.08 p.m.	.10	.08	.15	.30	.45	.52	.59	.65	.70	.73	.75	.80	.....	.....	.....
		28th.		11.05 p.m.	11.30 p.m.	4.10	.02	.05	.08	.11	.13	.15	.18	.25	.45	.65	.95	.....	.....	.....
Sept. 8-9.....	3.40 p.m.	12.10 p.m.	4.35	8.10 a.m.	8.22 a.m.	1.30	.07	.09	.15	.25	.31	.40	.45	.49	.57	.71	.77	.89	1.03	.....
		9th.		9.12 a.m.	10.25 a.m.	.30	.05	.22	.47	.70	.87	1.12	1.33	1.36	1.57	1.72	2.07	2.44	2.52	.....
13.....	7.20 p.m.	11.45 p.m.	1.49	7.52 p.m.	8.37 p.m.	.08	.06	.11	.20	.30	.50	.68	.78	.92	1.00	1.02	1.05	1.11	1.18	1.23
Oct. 3.....	10.10 a.m.	12.40 p.m.	2.13	10.50 a.m.	11.03 a.m.	.10	.12	.26	.40	.46	.48	.50	.57	.60	.63	.75	1.35	1.81	2.06	.....
Nov. 27.....	9.30 a.m.	5.00 p.m.	.69	11.33 a.m.	12.00 p.m.	.20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
				9.58 a.m.	12.08 p.m.	.06	.15	.40	.50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1894.																				
June 23.....	12.30 p.m.	2.30 p.m.	.94	12.30 p.m.	12.55 p.m.	.00	.10	.35	.55	.73	.80	.84	.87	.90	.....	.....	.....	.....	.....	.....
July 3.....	10.25 a.m.	11.00 a.m.	.42	10.25 a.m.	10.40 a.m.	.00	.10	.28	.40	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
18.....	7.22 p.m.	11.35 p.m.	2.42	7.37 p.m.	8.12 p.m.	.05	.30	.70	1.20	1.40	1.55	1.60	1.75	1.80	1.85	1.90	(a)	.....	.....	.....
31.....	2.45 p.m.	5.20 p.m.	.99	3.07 p.m.	3.32 p.m.	.05	.30	.40	.52	.57	.65	.69	.74	.80	.85	.....	.....	.....	.....	.....
Aug. 17.....	6.06 p.m.	11.40 p.m.	2.11	7.07 p.m.	7.50 p.m.	.20	.02	.05	.12	.29	.55	.85	1.15	1.32	1.42	1.47	1.55	.....	.....	.....
1895.																				
Apr. 24.....	1.05 p.m.	3.40 p.m.	1.27	1.20 p.m.	1.38 p.m.	.05	.10	.19	.26	.34	.39	.46	.49	.56	.66	.89	1.00	1.07	1.12	1.15
May 24.....	4.35 p.m.	5.20 p.m.	.55	1.58 p.m.	2.12 p.m.	.20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
June 13.....	1.07 p.m.	1.40 p.m.	.94	4.42 p.m.	4.55 p.m.	.05	.04	.10	.30	.45	.50	.....	.....	.....	.....	.....	.....	.....	.....	.....
16-17.....	3.45 p.m.	1.00 a.m.	3.19	1.12 p.m.	1.35 p.m.	.05	.05	.20	.47	.67	.84	.94	.....	.....	.....	.....	.....	.....	.....	.....
		17th.		7.52 p.m.	8.30 p.m.	.85	.04	.18	.35	.42	.55	.65	.83	1.00	1.12	1.30	1.43	1.67	1.80	1.91
July 24.....	12.30 p.m.	1.30 p.m.	.85	12.37 p.m.	12.55 p.m.	.05	.03	.15	.40	.50	.70	.77	.80	.....	.....	.....	.....	.....	.....	.....
7.....	3.00 p.m.	4.40 p.m.	.55	3.12 p.m.	3.27 p.m.	.05	.23	.30	.40	.45	.47	.....	.....	.....	.....	.....	.....	.....	.....	.....
12.....	1.23 p.m.	2.20 p.m.	.54	1.47 p.m.	2.07 p.m.	.05	.10	.15	.22	.44	.47	.49	.....	.....	.....	.....	.....	.....	.....	.....
13.....	5.04 p.m.	6.04 p.m.	2.28	5.04 p.m.	5.30 p.m.	.00	.20	.70	1.25	1.70	1.80	1.82	1.85	2.01	2.16	2.23	2.28	.....	.....	.....
25-26.....	8.40 p.m.	About 3.00 a.m. 28th.	2.39	5.40 p.m.	5.52 p.m.	.05	.24	.10	.29	.49	.68	.87	1.11	1.23	1.26	1.27	1.28	1.35	1.66	1.86
Aug. 3.....	2.46 p.m.			4.54 p.m.	5.48 p.m.	.44	.10	.20	.38	.57	.64	.73	.85	1.15	1.45	1.70	1.87	2.05	.....	.....
3.....		10.05 p.m.	3.84	6.28 p.m.	6.42 p.m.	.35	.03	.06	.10	.17	.35	.67	.72	.80	.83	.86	.90	.....	.....	.....
4.....	6.55 a.m.	7.30 a.m.	.53	7.00 a.m.	7.10 a.m.	T.	.20	.45	.47	.48	.50	.53	.....	.....	.....	.....	.....	.....	.....	.....
17.....	4.55 p.m.	5.50 p.m.	.36	5.03 p.m.	5.10 p.m.	.05	.01	.12	.30	.34	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
22.....	11.52 a.m.	1.55 p.m.	1.45	12.07 p.m.	12.30 p.m.	.05	.17	.30	.55	.67	.81	.83	.85	.86	.87	.89	1.15	1.36	1.40	.....
22.....	4.38 p.m.	6.00 p.m.	.85	12.57 p.m.	1.13 p.m.	.10	.00	.22	.30	.42	.68	.80	.81	.....	.....	.....	.....	.....	.....	.....
1896.																				
Apr. 24.....	5.30 p.m.	8.45 p.m.	1.30	7.06 p.m.	7.27 p.m.	.20	.05	.10	.13	.15	.20	.45	.67	.80	.87	.93	1.02	1.10	1.25	.....
July 7.....	9.45 a.m.	11.10 a.m.	1.84	9.55 a.m.	10.13 a.m.	.05	.02	.05	.30	.65	.90	1.05	1.10	1.11	1.12	1.13	1.15	1.30	.....	.....
Aug. 18.....	5.45 p.m.	10.45 p.m.	2.68	8.33 p.m.	8.56 p.m.	1.46	.25	.50	.70	.95	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....
26.....	4.30 a.m.	5.35 a.m.	1.63	4.42 a.m.	5.19 a.m.	.10	.05	.08	.15	.27	.38	.62	.97	1.25	1.45	1.57	1.63	.....	.....	.....
ST. LOUIS, MO.																				
1889.																				
Sept. 4.....	3.15 p.m.			3.15 p.m.	3.20 p.m.	.00	.25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
5.....		1.10 a.m.	1.85	10.10 p.m.	10.35 p.m.	.55	.15	.38	.48	.55	.71	.74	.76	.78	.80	.85	.95	.....	.....	.....
1890.																				
June 17.....	5.15 p.m.	6.00 p.m.	.66	5.15 p.m.	5.33 p.m.	.00	.06	.25	.40	.47	.50	.54	.61	.65	.....	.....	.....	.....	.....	.....
1891.																				
June 8.....	12.03 a.m.	1.25 a.m.	1.25	12.03 a.m.	12.43 a.m.	.00	.18	.38	.45	.53	.62	.73	.80	.85	.89	.93	1.02	1.25	.....	.....
16.....	1.58 p.m.	5.20 p.m.	1.10	1.58 p.m.	2.10 p.m.	.00	.10	.25	.30	.32	.35	.....	.....	.....	.....	.....	.....	.....	.....	.....
20.....	3.15 a.m.	5.45 a.m.	.95	3.38 p.m.	4.04 p.m.	.05	.20	.32	.39	.45	.55	.59	.60	.....	.....	.....	.....	.....	.....	.....
Aug. 11.....	12.25 p.m.	2.00 p.m.	.85	3.29 a.m.	3.39 a.m.	.05	.23	.46	.51	.54	.56	.59	.60	.62	.63	.64	.68	.78	.84	.90
17-18.....	11.55 p.m.	5.40 a.m.	.55	4.22 a.m.	4.30 a.m.	.15	.05	.30	.40	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
		18th.																		
1892.																				
July 13.....	4.30 a.m.	7.55 a.m.	1.38	4.59 a.m.	5.17 a.m.	.05	.35	.57	.62	.67	.69	.70	.71	.72	.73	.74	.75	.97	1.28	.....
Aug. 7.....	2.25 a.m.	4.30 a.m.	.94	2.32 a.m.	2.48 a.m.	.05	.40	.51	.70	.77	.79	.80	.85	.....	.....	.....	.....	.....	.....	.....

a Gauge ceased to register at 8.27 p. m.

b Gauge overflowed.

c Partly estimated.

d About.

TABLE VIII.—Details of excessive rainfall, Washington, Savannah, and St. Louis—Continued.

Station and date.	Total duration.		Total amount of precipita- tion (inches).	Excessive rate.		Amount before excessive rate began (inches.)	Depths of precipitation (in inches) during periods of time as indicated.													
	From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
ST. LOUIS, MO.— continued.																				
1893.																				
May 25-26.....	10.30 p. m. 25th.	2.15 p. m. 26th.	a 3.25	10.21 a. m. 26th.	10.40 a. m.	2.05	0.15	0.33	0.42	0.50	0.53	0.55	0.57	0.59	0.60	0.65	0.67	0.71	0.75	....
July 28-29.....	9.15 p. m. 28th.	1.30 a. m. 29th.	.92	9.39 p. m.	9.59 p. m. 28th.	.05	.05	.20	.45	.57	.68	.80	.85	.....	.....	.....	.....	.....	.....	.....
1894.																				
July 28.....	9.10 p. m.	11.50 p. m.	.92	9.10 p. m.	9.30 p. m.	.00	.11	.33	.50	.60	.64	.65	.66	.68	.71	.71	.72	.76	.84	0.88
Sept. 4.....	3.48 p. m.	5.55 p. m.	.79	4.55 p. m. 5.25 p. m.	5.00 p. m. 5.35 p. m.	.31 .07	.04	.09	.14	.18	.20	.24	.28	.41	.46	.47	.48	.74	.....	.....
1895.																				
June 17.....	5.18 p. m.	9.30 p. m.	.64	5.18 p. m.	5.30 p. m.	.00	.25	.37	.42	.45	.47	.49	.51	.52	.....	.....	.....	.....	.....	.....
July 27.....	4.30 a. m.	8.30 a. m.	b 2.48	5.20 a. m.	5.40 a. m.	T. .00	.06	.15	.19	.21	.33	.45	.62	.77	.....	.....	.....	.....	.....	.....
29.....	9.38 a. m.	1.10 p. m.	c 1.29	9.38 a. m. 11.43 a. m.	10.48 a. m. Noon.	.00 .20	.08	.20	.....	.18	.18	.18	.25	.59	.89	.96	.97	1.02	1.07	1.08
29.....	6.50 p. m.	10.30 p. m.	1.59	6.50 p. m. 8.00 p. m.	7.10 p. m. 8.15 p. m.	.00 .05	.26	.38	.57	.69	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1896.																				
May 11.....	12.25 p. m.	1.42 p. m.	.59	12.50 p. m.	1.10 p. m.	.04	.01	.03	.06	.25	.35	.50	.59	.....	.....	.....	.....	.....	.....	.....
13.....	6.28 p. m.	9.40 p. m.	.63	6.35 p. m.	6.40 p. m.	T. .00	.34	.41	.44	.45	.46	.47	.48	.49	.51	.53	.55	.59	.61	.63
18.....	11.30 p. m.	.....	.....	11.40 p. m.	11.50 p. m.	.07	.02	.19	.32	.34	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
19.....	.....	6.55 a. m.	1.46	3.10 a. m. 3.40 a. m.	3.15 a. m. 4.03 a. m.	.13 .03	.11	.11	.12	.13	.13	.14	.23	.30	.50	.59	.69	.72	.....	.....
21.....	7.05 p. m.	7.35 p. m.	.42	7.05 p. m.	7.10 p. m.	.00	.30	.36	.40	.41	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
27.....	5.43 p. m.	.....	.....	6.04 p. m.	7.00 p. m.	.01	.01	.01	.08	.16	.29	.50	.72	.84	.95	1.00	1.23	d 1.34	.....	.....
27.....	.....	10.05 p. m.	2.89	7.23 p. m. 8.08 p. m.	7.35 p. m. 8.18 p. m.	T. .07	.23	.66	.70	.70	.70	.71	.71	.71	.76	.83	1.01	1.16	1.35	1.43
June 7-8.....	11.12 p. m. 7th.	1.30 a. m. 8th.	.53	11.33 p. m.	11.40 p. m. 7th.	.02	.13	.21	.22	.26	.35	.42	.....	(e)	.....	.....	.....	.....	.....	.....
21.....	2.33 p. m.	8.20 p. m.	.58	2.53 p. m.	3.03 p. m.	T. .21	.54	.58	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
25.....	8.54 p. m.	Midnight.	.58	9.20 p. m. 9.50 p. m.	9.25 p. m. 10.00 p. m.	T. .13	.10	.15	.18	.20	.21	.23	.34	.45	.48	.50	.51	.53	.57	.58
July 13.....	2.21 p. m.	2.52 p. m.	.35	2.38 p. m.	2.45 p. m.	.03	.03	.03	.12	.35	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
20.....	12.40 a. m.	2.00 p. m.	1.06	1.35 a. m.	1.50 a. m.	.29	.01	.03	.10	.15	.21	.22	.27	.43	.59	.72	.78	.94	.....	.....
21.....	8.34 a. m.	1.55 p. m.	.91	8.40 a. m.	9.00 a. m.	T. .22	.40	.52	.66	.72	.76	.76	.78	.80	.82	.85	.88	.....	.....	.....
22.....	7.23 p. m.	8.33 p. m.	.36	7.33 p. m.	7.48 p. m.	T. .16	.24	.36	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Aug. 12.....	1.43 p. m.	7.15 p. m.	.60	8.05 p. m.	8.10 p. m.	.19	.04	.06	.09	.09	.09	.09	.12	.14	.14	.35	.....	.....	.....	.....
16.....	12.18 a. m.	4.15 a. m.	1.29	12.40 a. m. 2.00 a. m.	12.55 a. m. 2.20 a. m.	.08 .12	.06 .02	.09	.18	.34	.38	.40	.....	.....	.....	.....	.....	.....	.....	.....
Sept. 26.....	6.40 p. m.	8.35 p. m.	.41	6.55 p. m.	7.05 p. m.	.09	.02	.09	.20	.28	.33	.33	.34	.....	.....	.....	.....	.....	.....	.....

a Of this amount (3.25), 2.05 fell between 10.30 p. m., 25th, and 7 a. m., 26th; .45 fell between noon, 26th, and 2.15 p. m., 26th.

b At 5.40 a. m. instrument failed to record: 1.71 fell between 5.40 and about 8.30 a. m.

c Of this amount (1.29), 0.20 inch fell between 11. a. m. and 11.43 a. m.

d Fell between 5.43 and 7.05 p. m.

e .11 fell between midnight and 1.30 a. m. 8th.

f T. fell after 7.48 p. m.

TABLE IX.—Maximum intensity of rainfall for periods of 5, 10, and 60 minutes at Weather Bureau stations equipped with self-registering gauges, compiled from all available records.

Stations.	Rate per hour for—			Stations.	Rate per hour for—		
	5 min-utes.	10 min-utes.	60 min-utes.		5 min-utes.	10 min-utes.	60 min-utes.
	Inches.	Inches.	Inches.		Inches.	Inches.	Inches.
Bismarck.....	9.00	6.00	2.00	Chicago.....	6.60	5.92	1.60
St. Paul.....	8.40	6.00	1.30	Galveston.....	6.48	5.58	2.55
New Orleans.....	8.16	4.86	2.18	Omaha.....	6.00	4.80	1.55
Milwaukee.....	7.80	4.20	1.25	Dodge City.....	6.00	4.20	1.34
Kansas City.....	7.80	6.60	2.40	Norfolk.....	5.76	5.46	1.55
Washington.....	7.50	5.10	1.78	Cleveland.....	5.64	5.66	1.12
Jacksonville.....	7.44	7.08	2.20	Atlanta.....	5.46	5.46	1.50
Detroit.....	7.20	6.00	2.15	Key West.....	5.40	4.80	2.25
New York City.....	7.20	4.92	1.60	Philadelphia.....	5.40	4.02	1.50
Boston.....	6.72	4.98	1.68	St. Louis.....	4.80	3.84	2.25
Savannah.....	6.60	6.00	2.21	Cincinnati.....	4.56	4.20	1.70
Indianapolis.....	6.60	3.90	1.60	Denver.....	3.60	3.30	1.18
Memphis.....	6.60	4.80	1.86	Duluth.....	3.60	2.40	1.35

